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U. S. DEPARTMENT OF AGRICULTURE

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A REPORT

ON THE

WORK AND EXPENDITURES OF THE

AGRICULTURAL EXPERIMENT

STATIONS

DURING THE FISCAL YEAR ENDED

JUNE 30, 1914

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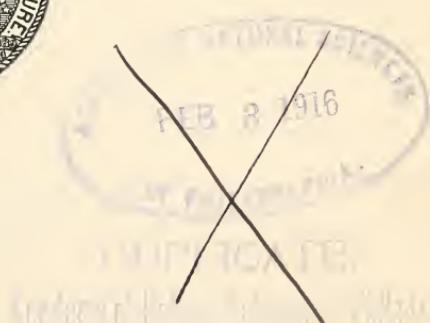
U. S. DEPARTMENT OF AGRICULTURE.

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EXPERIMENT STATIONS

DURING THE FISCAL YEAR  
ENDED JUNE 30,  
1914.



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## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
OFFICE OF EXPERIMENT STATIONS,  
*Washington, D. C., June 25, 1915.*

SIR: I have the honor to transmit herewith a report on the work and expenditures of the agricultural experiment stations during the fiscal year ended June 30, 1914, as required by law. The report also contains a brief statement of the relations of the Office of Experiment Stations with the agricultural experiment stations of the several States and Territories.

Very respectfully,

A. C. TRUE, *Director.*

Hon. D. F. HOUSTON,

*Secretary of Agriculture.*



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# WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1914.

By E. W. ALLEN and E. V. WILCOX.

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## RELATIONS OF THE OFFICE OF EXPERIMENT STATIONS WITH THE AGRICULTURAL EXPERIMENT STATIONS.

The agricultural experiment stations with which the Office of Experiment Stations has official relations fall into two classes—the State experiment stations and the insular experiment stations. The former are State institutions supported in part by funds given by the Federal Government to the States. The direct management of these stations is wholly in the hands of State officers. The appropriations, however, called for by the Hatch Act and Adams Act are made by Congress from year to year and come under the head of annual appropriations for the Department of Agriculture. In the case of the insular stations in Alaska, Hawaii, Porto Rico, and Guam, on the other hand, all appointments are made by the Secretary of Agriculture. There is no local governing board for these insular stations, and the supervision of funds and the determination of the policy of the stations originates from the office under authority from the Secretary.

The Hatch Act providing funds for the support of agricultural experiment stations in the various States, passed in 1887, provided for an agency within the Department of Agriculture to represent it in its relations with the experiment stations, and the duties of the office then established have been extended by subsequent legislation to include supervision of the Federal appropriations for the stations and the use made of them under the appropriating acts. These duties, with the advisory relations and various efforts to aid the stations, constitute the main function of the office, although a number of other lines of work have been assigned to it from time to time.

The office maintains very intimate relations with the stations in the several States, with the result that all of them are bound together into a national system, while retaining their individual autonomy and management. The functions of the office are therefore partly supervisory and partly advisory. An annual inspection of the stations is made for the purpose of examining into their work and their expenditures under the Federal funds, and for inquiring into the relations and management of the stations as well as their general efficiency.

The determination of the legality of an expenditure from the standpoint of the Hatch Act and Adams Act involves a consideration of the whole work and general condition of the stations, their efficiency, relations, and general influence. No fixed rules can be established as to the amounts of money which may be legally expended for apparatus, salaries, and other purposes. These matters must be determined independently in each case after a consideration of the demands made upon the station and the facilities which it possesses for its work.

In this annual inspection the relations of the stations to the colleges of agriculture also receive attention, particularly the matter of division of salary of the station officials who are also teachers in the colleges, the purchase of equipment which is used jointly by the stations and colleges, and the use of funds in payment for the publication of bulletins and circulars which are and those which are not the result of experimental work by the station. In this inspection many problems are presented which could not be solved by an appeal to the terms of the law, but are adjusted, rather, by an appeal to good policy and the various interests involved. In this work a broad view of the functions of the stations has been taken, and in general an effort has been made to defend their interests and buildup their work without in any way diminishing their essential autonomy.

The office passes upon and approves the annual financial reports which are made by the experiment stations in accordance with the schedules prescribed by the Secretary of Agriculture and on the basis of which warrants are issued by the Treasury Department. Under the Adams Act the supervision of work and expenditures goes somewhat further, for the department is charged with the administration of this law as a whole.

The advisory relations of the office with the stations are concerned largely with their general policy, organization, relations to teaching and other lines of work, personnel, and similar matters. From its wide acquaintance with conditions and with the needs of the stations, the office is able to assist in recruiting their working force and maintains a register of available men for that purpose. Furthermore, the office points out the needs of the stations in buildings and equipment, urges the importance of arrangements which will insure time and liberty to station officials for their legitimate work, arrangements for cooperation and assistance, and advocates their cause generally. Its whole effort is directed toward furthering and strengthening the stations and their work by supervising their funds, protecting their interests, stimulating their activities along lines of genuine investigation, and maintaining a central agency for the experiment stations. The uniformly cordial relations which have existed have helped to make this effort effective.

The insular stations are upon a different basis. The office is in immediate charge of experiment stations in Alaska, Hawaii, Porto Rico, and Guam, the appropriations for which are made directly to the department. These stations are administered through local agents corresponding to the directors of State stations. The connection, however, is more intimate and the supervision is more far-reaching than in the case of State stations immediately responsible to their local boards.

In addition to these functions the office is charged with investigation in agricultural education, farmers' institutes, nutrition, irrigation, and drainage investigations. Through the medium of the Experiment Station Record, an abstract journal prepared in the office, the progress of agricultural investigations throughout the world is made readily available to station workers and others officially connected with the conduct of agricultural institutions.

#### REVENUES.

The income of the Office of Experiment Stations during the fiscal year ended June 30, 1914, was as follows:

##### Appropriations by Congress:

|  |              |
|--|--------------|
| For the general expenses of the office-----                                | \$106,660.00 |
| For the Alaska experiment stations-----                                    | 35,000.00    |
| For the Hawaii Experiment Station-----                                     | 30,000.00    |
| For the Porto Rico Experiment Station-----                                 | 30,000.00    |
| For the Guam Experiment Station-----                                       | 15,000.00    |
| For investigations on agricultural schools and<br>farmers' institutes----- | 23,000.00    |
| For nutrition investigations-----  | 16,000.00    |
| For irrigation investigations-----   | 108,000.00   |
| For drainage investigations-----   | 97,600.00    |
| Total appropriation-----   | 461,260.00   |

##### Sale of agricultural products at the insular experiment stations:

|                                    |           |
|------------------------------------|-----------|
| Alaska experiment stations-----    | 12,740.79 |
| Hawaii Experiment Station-----     | 704.54    |
| Porto Rico Experiment Station----- | 2,699.85  |
| Guam Experiment Station-----       | 361.05    |

|                       |            |
|-----------------------|------------|
| Total from sales----- | 16,506.23  |
| Total income-----     | 477,766.23 |

#### REVIEW OF THE YEAR.

The year 1914 was one of increasing growth and achievement for the experiment stations. State appropriations to the stations increased by \$767,588 over those of 1913. Additional appointments were made to strengthen the force of workers and to extend the field of operations. Substantial advances were made in a number of

lines of investigation. An increase in the amount of published material occurred. At several stations changes were inaugurated in the organization of the staff in the interest of better coordination and cooperation of departments of research and of greater efficiency.

Most of the station investigators enjoyed further relief from the work of inspection, control, teaching, and extension. The necessities of research were recognized more fully by provision of better equipment and facilities for investigation of high grade. Some advance was noted in clarifying the conception of the position and relationships of the station and of its staff as members of a public institution for investigation. There occurred also in several instances an improvement in the reciprocal relations of station workers, directors, and governing boards. In short, a general advance was noted in the stations as organized agencies of agricultural research.

#### RELATIONS OF INVESTIGATION AND EXTENSION.

With the passage of the Smith-Lever Act a new era began for the experiment stations. As set forth by the committee on experiment station organization and policy at the annual convention of the agricultural colleges and experiment stations in 1914, "the extension work has developed very largely with and out of the work of experiment stations, and in a considerable number of cases has formed a feature of the stations' own activities. This fact has tended to broaden the conception of the station's field and popular expectation in regard to it. Instead of being strictly an institution for acquiring information through investigation and experiment, it has served, to some extent, for the popular dissemination of information regarding improved farm practice. The effect of this has been to confuse the public mind, and often many workers within the stations, as to the real function of the experiment station."

The station worker, by patient investigation, had first to establish a scientific basis for improved farming methods, and then, armed with this information, he was asked to go to the farmer and help translate science into practice. While the institution by this arrangement seemed to be securing a dual service from its staff, the old adage that a man can not serve two masters was soon demonstrated anew. A separation along the logical cleavage plane began to appear. The agricultural workers began to choose between the two lines of endeavor. Here and there was noted a reluctance on the part of station men to give up extension work, but they have at last come to the parting of the ways and agricultural workers must choose between research and extension. They can not take both roads.

There is little real basis for the slight jealousies sometimes felt by station men toward extension workers on account of the popular attention and newspaper notices which the latter may receive. Com-

parison of the two lines of work serves no purpose. Both are necessary, and both are provided for with separate funds. It remains for the workers in each field to cultivate their own field according to their best light and ability. There is work enough for all and glory enough also if the work is well done.

There is believed to be little real occasion for fear that adequate support for research work will not be continued. In the State appropriations for 1914 large sums were specifically set aside for investigation. The research work of the experiment stations furnishes the essential basis upon which the extension worker and college teacher must rely. The teachings of extension and college men are subject to constant revision to bring them into harmony with advancing scientific discovery. Many of the accepted tenets of agricultural teaching will require submission to a further searching analysis. There is need to know to a greater degree of certainty whether the things taught are actually so. The more serious thinkers among agricultural teachers and investigators recognize that "to many of the agricultural problems which the extension men will encounter in their work among farmers no solution, or at best a very imperfect solution, is now available." As suggested in the presidential address of the convention of the agricultural colleges and experiment stations in 1914, "the more the extension workers, and to a considerable extent the agricultural people with whom they work, come to realize that our present knowledge will only go a little way toward solving the multitudinous problems of agriculture the more widespread and insistent will be the demands for more numerous and thorough investigation of these problems. It is therefore very important that we should consider the actual status of our research institutions and, while rejoicing in their many good features and their valuable work, should be active in remedying their deficiencies and in enlarging their services."

The work of the investigator obviously lies at the foundation of the whole superstructure of teaching and extension of agriculture. There is evidence of a growing tendency definitely to recognize this fact and to emphasize the source of the knowledge which is conveyed by the extension worker and teacher to their broad constituency. While the plain duty and function of the experiment-station man lies in the field of research, it is not necessary for him to lose touch with practice or with the farming public. The work of research, the formation of hypotheses, and the establishment of general principles naturally require that the research worker shall, at frequent intervals, face the actual facts of practical agriculture with his theories and laboratory findings, in order to gain new light for the interpretation of his discoveries and to bring them into alignment with rigid reality.

**SUPPORT FOR STATION WORK.**

Some readjustment of the funds provided for experiment-station work proper will doubtless occur. The funds which were previously expended for extension work will henceforth go into a separate fund and will be at the service of a separate body of workers. This transfer of the line of work and the funds provided for the work, however, will not in any way affect the amount of funds available for real station work. The station workers and the station as an institution will be relieved of numerous time-consuming duties, which have in many instances heretofore greatly interfered with the proper function of the experiment station. The funds available to the station will thereby be relieved of all other calls except those connected with investigation and experiment.

In the appropriations for some of the agricultural colleges and experiment stations the amount of money to be devoted to experimental work is not specified, but is left more or less to the discretion of the governing board. There is a natural tendency in legislatures, however, to guard the right of specifying the various purposes for which appropriations for the colleges and stations shall be spent. The allotment of funds by the governing board to the college and the station involves a responsibility which could, in some cases perhaps, be better assumed by the legislature. At any rate, in most, if not in all, instances it would seem that the needs of the station ought to be set forth in the budget of the institution in order that the status and demands of the experiment station as an institution of research may be definitely considered by the State legislatures during the discussion of the appropriation bill. This would serve to call attention to the functions and essential purposes of the experiment station as an agency of research.

**STATION ADMINISTRATION.**

The manner in which the director of the station may best direct the work and destiny of the station frequently becomes a subject for serious discussion, but is perhaps too often left to the chance decision of traditional methods and local conditions. In stations where the staff is small and the lines of work few, it is quite possible for the director to reserve for himself some line of investigation which he may carry on or participate in in a more or less connected manner. With the usual growth in the complexity of relations of the station to farmers and communities and with the corresponding growth in the staff of the station, it soon becomes quite impossible for the director to carry on research work with any degree of satisfaction. The question is often raised as to whether a director under such circumstances should devote his energies chiefly to administration and to the relations be-

tween the station and its constituency, or whether he should become in fact also a director of the research work of the station.

The possibilities of service on the part of the director in inspiring and giving encouragement and definiteness to the research work of the various members of the staff are so great and of such vital importance to the progress of the research work that grave doubt must be felt whether a director is justified in not assuming such a function of leadership. Even a cursory examination of the instances of the lapse of projects through faulty organization, loss of interest, or lack of real leadership and inspiration will show that the director of the station could usually have prevented such an occurrence by a timely and friendly inquiry into the actual status of the project, the needs which had arisen in connection with the work, and the perplexities into which the workers had fallen.

Some station directors assume that it is impossible for one man to assume the duty of directing research in a number of fields. It is obviously not necessary, however, for the director to be more advanced or superior in the line of work than the staff member who has that work immediately in charge in order to be of service; the sympathy and friendly interest and understanding of the director is very often of such inspirational value as to make important differences in the rate of progress and the decisiveness of the results.

At several of the stations changes in organization were made for the purpose of securing a better supervision and administration of the work and also to bring about a better cooperation of the different departments. The basis for a grouping of the departments differs somewhat in the different States where any system of grouping has been adopted. In several instances agronomy and soil investigations have been brought together as too intimately associated for strictly separate operations. A decided change has occurred in the point of view adopted in attempts at classifying or cataloguing the lines of station investigation, and often in organizing the work under them.

A problem in animal nutrition may be pursued chiefly from the standpoint of the animal husbandman, with whom may be brought into cooperation the chemist and the veterinarian. In another case, the problem with a very similar title might be approached chiefly from the chemical point of view, with the chemist as leader, receiving the cooperation of the animal husbandman and veterinarian. In other words, specific problems or projects can no longer be made to fall strictly within the field of one of the old-time departments of the station, but cut across the boundary lines of several of these departments. The leader of such a cooperative problem in each instance will be determined by the point of view from which the

problem is attacked. It is therefore quite possible for a director of the station to organize a different cooperative grouping of the departments for different projects, according to the predominant point of view. Station work thereby falls into a series of problems involving the cooperation of a number of experts directed to one specific end rather than a more or less independent operation of departments.

#### DEVELOPMENT OF WORKING FORCES.

In developing and strengthening their working forces a number of the stations have adopted plans for encouraging the members of the staff to go to other institutions for advanced study. This recognizes that to a certain extent the stations must aid in training their men. The Wyoming station has had excellent success from putting this plan in operation, and several stations have made special work in research a requirement for advancement beyond a certain point or grade. At least one institution, the Illinois Experiment Station, has considered the matter of providing a limited number of scholarships carrying an allotment of State funds for study away from the institution in preparation for station service. During the year the Florida Experiment Station gave leave of absence to its assistant plant pathologist to do advanced work in Harvard University; the chemist of the Idaho station was likewise given a furlough for advanced work at Cornell; and other institutions extended similar privileges. The Maine Experiment Station has adopted a plan of supplementing its force by employing entomological specialists from other institutions for special work in summer. The tendency is noted in a number of stations to give leave of absence for special work not connected with institutions of learning.

There is an increasing tendency to credit station work toward higher degrees and to accept station bulletins as part fulfillment of the requirements of a Ph. D. degree. This is a definite recognition on the part of higher institutions of learning of the equality of research work at stations with similar work at other institutions. As a rule, the work of the station man at the station has been accepted as satisfying all the requirements for a Ph. D. degree, except the one year of resident work, which is the minimum requirement of higher institutions of learning.

When it is remembered how expensive the training of men for their research work is to the stations, and how frequently changes occur with their serious consequences to the station work, the problem of increasing the permanency of the station staff is worth serious consideration. In former years the chief complaint of these men was that the tenure of office was uncertain, owing to changes in the executive boards and political influence brought to bear upon

such boards. At the present time, however, the individual station man may enjoy more security than does the institution. With the great increases which have taken place in the State appropriations in a few cases, these favored stations have been in a position to offer highly attractive salaries to the staff members. These inducements have been only too frequently sufficient to call the man away from his old line of work, with great injury to his station and in some cases with little benefit to the station where these new duties were assumed.

It is usually impossible for a man to reach his highest efficiency in a new locality until he has served there for a considerable period. He must, of course, first be brought into harmony and understanding with his environment before much confidence can be placed in his ability to judge the needs of the institution. The man who has been at a station for some time and has shown pronounced ability is a greater asset than a better trained man new to the locality, provided the old employee can be induced, under proper conditions, to secure the advanced intellectual equipment which he will need to keep pace with the growth of his work.

#### THE PROJECT SYSTEM.

The project system as a basis for administering the work and funds of experiment stations has proved satisfactory in all respects, and its advantages are receiving more and more recognition with each year of its operation. Some of the advantages of this system, as summarized in a paper before the experiment station section at the convention of agricultural colleges and experiment stations in 1914, are as follows:

"It insures more thorough planning; it enables a proper consideration of new undertakings before funds are assigned to them; it provides a record of the station's activities; it enables the work to be followed up from time to time and to be concluded when it ceases to be profitable; it assists in defining the scope of the station work and in holding it within its proper field; it tends toward general economy; it enables a budget to be made up intelligently in accordance with the needs or relative importance of individual undertakings; it provides against inadvertently overloading the program of work so that features of it become ineffective for lack of funds; it gives an effective basis for discussing and reporting upon the station's work and for explaining the use of its funds."

That the merits of this system are appreciated is emphasized by the increasing extent to which the work is being organized and stated on a definite project basis. At many of the stations this plan is now followed in all the work, whether under Federal or State

funds. This is usually accompanied by a budget or estimate of financial needs, which makes provision for each project.

The advantages of the project system are specially apparent in the economy and efficiency in the expenditure of station funds. The necessity of definite plans along the lines of specific projects for the use of all the funds of the stations becomes more and more obvious. There is a serious danger of wasteful expenditure of funds unless some such plan is followed, which places each undertaking on its own merits each year, as a means of justifying the continuance of financial support. This is most strikingly true in those instances where the station receives large State appropriations in lump sums. Unless care and supervision are exercised to guard against projects running to seed or continuing from year to year in a purely routine way, there is danger that the law of diminishing returns may apply to the constantly increasing funds.

#### DUPLICATION IN STATION WORK.

Occasionally the criticism is made that there is too much duplication of one another's work in the experiment stations as a whole. This criticism, however, seems to have in view an apparent rather than a real duplication of work in the sense of an unnecessary repetition. Repetition of experiments is absolutely necessary for the establishment of scientific facts and principles. Experiments must be carried on cautiously and with constant reference to all of the local factors. It is a practical impossibility to estimate with absolute certainty the influence of all these factors or to avoid the occasional influence of some uncontrollable factor. The unknown quantities in the equations with which scientists work can therefore be determined only by restating the problem from a slightly different standpoint and apparently going over the work again. Certainty can rarely be achieved in any line from a single set of experiments, and especially where conditions are so complex as in agricultural problems. The necessity for repetition is no reflection upon the quality of station workers, but results from the complex interaction of the numerous factors which must be considered and from the extreme difficulty of so limiting an experiment that all uncontrolled factors are excluded.

An important instance of the necessity of the repetition of experiments may be seen in the recent experiment at the New York State station, where it was found that the dust in the air in milking stables was of relatively little importance in the bacterial contamination of milk. This was quite contrary to the generally accepted belief based on previous experiments, which makes necessary a reexamination of the problem of milk contamination, in which each

possible factor will need to be rigidly considered. Repetition will be necessary in many lines of scientific work. The kind of repetition to which reference is here made, however, is not a mere duplication in which the result may be foreseen and is more or less obvious, but a repetition for the purpose of subjecting some part of the problem to more searching analysis, usually from a new point of view, and for definitely determining whether certain accepted propositions are well founded.

#### DIGRESSIONS IN STATION INVESTIGATION.

There is a noticeable tendency in carrying out experiment-station projects to drift away from their proper sphere into the region of pure abstractions or laboratory formulas only remotely connected with agricultural investigation. Agricultural science has no fixed boundaries and the present-day investigation of agricultural problems very often necessitates excursions into what has been thought of as pure science. But this is no warrant for directing investigation into pure science lines with the end of advancing the broad field of science rather than that phase of it which bears on agriculture. The essential thing is that the problem is in agriculture, and that the investigation will not lose sight of its original object, but will be brought back to the problem as soon as possible. The station is not a place for pure research free from limitation. Its work has a definite and persistent agricultural purpose. The relationship of investigation to that purpose varies in directness, but it should not be so remote that it can not ultimately be justified in a tangible and satisfactory manner.

#### ADAMS FUND WORK.

The amount and character of investigation conducted under the Adams fund show gratifying progress from year to year. The Adams fund projects have attained a high grade, and the grade of work required under that fund has become a recognized standard of excellence. The same care and examination are given to new projects as formerly, and the entire list is scrutinized annually. As a result modifications are made from time to time to strengthen them or give greater definiteness of purpose, and occasional transfers are made to some other fund.

The aim of the Office of Experiment Stations in the matter of supervising the expenditure of the Adams fund is fundamentally of a constructive nature. Leaving the initiative in all cases to the stations, the whole purpose of such supervision is to bring about an economical and effective use of the fund for purposes for which it was provided and to promote investigation in the true sense. The attempt is made to reach a full understanding in each instance as

to the nature of the problems to be investigated, and particularly as to the proper limitations of each problem, the methods to be employed in attacking the problem, the provision of capable leadership and necessary facilities, and the amount of funds available for each project.

The requirement that a scientific project shall be clearly and adequately outlined in advance is not only necessary for an understanding of the project by this department, but is also equally necessary for the leader of the project. To prepare a clear and circumstantial statement of a project in advance requires on the part of the leader a clear and logical organization of the method of attack, and helps to give purpose and direction to the undertaking. Such constructive criticisms and suggestions as are made by the office are met with a fine spirit of reciprocation, recognizing the common end and aim in the strengthening of the investigations and making them contribute in the highest degree to the advancement of theory and practice.

During the year a total of 431 separate projects were in progress. Of this number 49 were new projects, originated at the commencement of or during the year. It is interesting to note that the largest number of projects fall under the head of studies of pathological and physiological diseases of plants, winter injury, fungicides, etc., and the second largest under the head of entomology and zoology, these being followed by plant-breeding projects. The classification is as follows:

Animal breeding 17, animal pathology 34, animal nutrition 25, poultry 6, animal industry—miscellaneous 4, dairy products 9, plant breeding 49, plant pathology, including fungus, bacterial, and physiological diseases, winter injury, and fungicides 74, soil chemistry—plant nutrition 37, plant chemistry 34, soil biology—nitrification, ammonification, and nitrogen fixation 24, plants—water requirements 13, field crops 12, horticulture 21, entomology and zoology 63, rural engineering 8, and meteorology 1.

The average number of projects to a station is about eight, but the number varies quite widely in different instances, in some cases only three or four studies being conducted under the Adams fund. To a considerable extent the Hatch fund and State funds are employed to supplement the Adams fund in conducting these investigations.

#### INCREASE IN FUNDS AND EQUIPMENT.

The total revenues available to the experiment stations, including the insular stations, for the fiscal year ended June 30, 1914, were \$5,164,687.96. Of this amount \$1,536,166.99 came from Federal appropriations, \$2,574,605.27 from State and Territorial appropriations, and \$1,053,715.70 from fees, contributions, the sales of farm products, and other sources. The stations thus derived a little less

than one-third of their total financial support from Federal funds and nearly one-half from State funds. The Alaska stations received \$5,000 more Federal money than in 1913. Otherwise the Federal appropriations for the stations remained the same as since 1911, when the funds appropriated under the Hatch and Adams Acts reached their prescribed maximum. The State and Territorial appropriations to the stations were greater by \$767,588.76 than in 1913. On the other hand, the station revenues derived from fees, sales of products, and other miscellaneous sources showed a decrease of \$353,586.56. The increase in State appropriations to the stations was more than twice as great as in 1913, and the total revenue of the stations during the year showed an increase over the previous year of \$405,169.19.

In Ohio the total revenue available to the station, including balances from the previous year, was \$481,418.82. In several other States the station funds reached large proportions. Thus in Minnesota the total station revenue was \$396,068.54; in Illinois, \$298,620.56; in Indiana, \$315,363.20; in Kentucky, \$285,753.93; in California, \$205,409.96; and in Iowa, \$162,086.26.

It is interesting to notice an increasing tendency in State legislatures to make permanent financial provision for the stations, either on a mill tax basis or by means of standing appropriations. Moreover, in a few instances the station appropriation act provides that the funds allotted to the station shall increase by a regular annual increment until a fixed maximum is reached. The keen, substantial interest of the States in support of the stations is evidenced by the fact that the State appropriations for the year were so largely increased that they not only offset the decrease of revenue from fees and miscellaneous sources, but provided an increase of \$405,169.19 over the total funds of the previous year.

Notwithstanding these substantially increased appropriations in the majority of States, there were still nine stations which received no direct support from the State. In each of these States the station urgently needs and richly deserves such help. The lack of it cripples the station in its work and prevents its attaining its full usefulness to the State. The limitations surrounding the two Federal funds make it exceedingly difficult to maintain the buildings and to meet the usual expectations and demands placed upon the stations.

Among the important State appropriations to the stations and increases in equipment during the year, the following are of interest:

In Arizona funds were provided for a new farm near Mesa, in Salt River Valley, for the use of the station. This farm has an area of 160 acres. The total State appropriation to the station was \$30,000.

In addition to the usual large appropriation from the State, the California station was provided with \$870 for an insectary, \$2,600

for two greenhouses, \$5,000 for a hog-serum laboratory, and \$1,250 for the purpose of an addition of 10 acres to the Imperial Valley farm, making the total area of this farm 40 acres.

In Hawaii the Territorial legislature provided \$15,000 for use in developing substations on the various islands and in establishing a marketing system for the better handling of miscellaneous farm products.

The Illinois Legislature voted the large sum of \$195,000 for investigational work in the various departments of the station.

At the Indiana station \$15,000 were received for hog-cholera work, \$15,000 for soil improvement, and \$10,000 for dairy work, the total State appropriation to the station being \$75,000.

At the Kansas station the substation work was strongly encouraged by appropriations made for the specific purpose of increasing the effectiveness of station work through the substations. The total State appropriation to the station was \$92,000. Perhaps the most complete experimental flour mill in the country was erected, at a cost of \$10,000.

The Maine Legislature voted a continuous appropriation to the experiment station of \$5,000 a year for use in animal-industry work and \$10,000 for the purchase of a farm in Aroostook County, where much of the experimental work in potatoes and other field crops will be carried on.

The total State and miscellaneous funds available for the Maryland station during the year were \$20,500. The legislature made an appropriation for investigations in soil fertility of \$10,000 for the year 1915 and \$20,000 for the year 1916.

The State funds granted to the Massachusetts station amounted to \$20,000, and provision was made that these funds should be increased \$5,000 annually for the next four years.

The Minnesota station received \$366,068.54 from State and miscellaneous funds for the construction of greenhouses, storage cellar, grain storage and cleaning plant, investigational work, and miscellaneous purposes.

In Mississippi the experiment station was provided \$33,525 from State funds for substations, including demonstration work and \$1,000 for the printing of popular bulletins.

An appropriation of \$50,000 was made for a hog-cholera-serum plant for the Missouri station. This plant will be located on 90 acres of land, devoted exclusively to work with hog-cholera serum. The station also received \$6,000 for a soil survey and \$10,000 for experiments with soils and crops.

The total State and miscellaneous funds available to the Montana station were \$38,498.44, to be applied to the general maintenance of

the station, the management of demonstration farms and the horticultural substation, and for the construction of a grain laboratory.

The Nebraska station received through State appropriations \$20,000 for investigations, \$47,750 for substations, and \$10,000 for the production of hog-cholera serum.

At the New York Cornell station a special fund of \$3,600 was received from the State for use in experimental work in plant breeding.

The State appropriations voted to the New York State station included \$52,000 for salaries, \$16,000 for labor, \$24,000 for general expenses, \$7,500 for grape investigations, \$15,500 for field and orchard work and a study of sanitary milk, and \$5,000 for hop cultivation.

The work of the New Jersey stations was supported by State appropriations of \$25,000 for salaries and general expenses, \$30,000 for mosquito extermination, \$6,500 for poultry husbandry, \$2,000 for seed control, \$3,000 for floriculture, \$5,000 for farm demonstration, and \$5,000 for printing bulletins.

The State legislature provided the North Dakota station with \$12,000 for demonstration farms, \$5,000 for branch stations, and \$5,000 for the purchase of live stock.

The revenue available to the Ohio station during the year was larger than that of any other station. Special State appropriations were made of \$40,000 for an addition to the station library, \$111,000 for personal service, and \$90,000 for maintenance.

The total State and miscellaneous funds available to the Oregon station were \$104,716.21. These funds were used for branch stations and the erection and equipment of barns and poultry buildings, as well as for general maintenance.

The Pennsylvania station received from the State legislature special appropriations of \$6,000 for tobacco experiments, \$75,000 for a horticultural building, and \$25,000 for dairy barns.

In South Dakota the station received \$11,000 for the support and equipment of substations and \$1,000 for the printing of popular bulletins.

For the maintenance of 11 substations in Texas the State legislature provided \$41,250. The station was also voted a special appropriation of \$2,000 for work in sheep breeding and \$3,000 for the publication of bulletins.

The total State and miscellaneous funds available to the Utah station were \$21,132.02, devoted to the erection of a brooder house, colony houses, a silo, and miscellaneous purposes.

Special provision was made by the Virginia Legislature for the conduct of county experiment stations, for which an appropriation of \$21,250 was voted. The Virginia truck station received \$10,000 for general purposes, including \$2,500 for an office building.

The State of Washington appropriated for the general use of the station \$9,000, which was an increase of \$4,000 over the appropriation of the previous year.

The State funds received by the West Virginia station included \$4,000 for the promotion of horticulture, \$1,500 for investigation of the live-stock industry, \$1,000 for tobacco investigations, \$1,000 for poultry work, and \$1,500 for printing bulletins.

The Wisconsin station had the use of \$62,016 from State and miscellaneous sources for maintenance and general purposes, as well as for special investigations in the different departments of the station.

#### CHANGES IN PERSONNEL.

The staff members of the stations engaged in work of administration and research during the fiscal year numbered something over 1,800. In this membership of the station staffs changes occurred affecting about 370 positions, including appointments, resignations, and transfers. Changes in the directorship occurred in five stations. At the Nevada station G. H. True resigned to accept a position in the California station and was succeeded by S. B. Doten. At the North Dakota station President J. H. Worst resigned the directorship of the station and Thomas P. Cooper was appointed to that position. In Oklahoma J. A. Wilson was replaced during the year by L. L. Lewis as acting director. In Oregon James Withycombe resigned the directorship after 14 years of service and was succeeded by A. B. Cordley, entomologist of the station. In Virginia S. W. Fletcher resigned as director of the station and W. J. Schoene was appointed acting director.

Among the other important changes in personnel of the stations mentioned may be made the following: J. M. Jones, head of the department of animal industry of the Alabama station, was succeeded by G. S. Templeton; Ernest Walker was appointed head of the horticultural department. At the Arizona station W. H. Lawrence received an appointment as horticulturist, and J. C. T. Uphof as assistant plant breeder. W. H. Wicks was appointed horticulturist at the Arkansas station. At the California station F. W. Woll was appointed in charge of animal nutrition, G. H. True animal husbandman, J. W. Gilmore agronomist, and J. T. Barrett plant pathologist. At the Colorado station E. R. Bennett, horticulturist, was succeeded by E. P. Sandsten. The Georgia station strengthened its staff by the appointment of B. B. Higgins as botanist, C. A. Wells as chemist, and C. K. McClelland as agronomist. In Guam L. B. Barber was appointed veterinarian of the station, and J. B. Thompson was succeeded at the end of the year by A. C. Hartenbower as special agent in charge.

At the Iowa station H. B. Munger was appointed chief in farm management. W. S. Anderson assumed charge of horse husbandry at the Kentucky station. In Louisiana W. E. Cross resigned as chemist at the Sugar station and A. P. Kerr was made assistant director of the State station. F. M. Surface returned as biologist in charge of plant breeding at the Maine station. In Michigan M. M. McCool succeeded J. A. Jeffery as head of the soils department and H. J. Eustace was appointed vice director. At the Mississippi station J. M. Beal was appointed plant pathologist and A. B. McKay resigned as horticulturist. A. Atkinson returned to the Montana station as agronomist and P. N. Flint was appointed animal husbandman. At the Nebraska station F. J. Alway, chemist, was succeeded by F. W. Upson. In Nevada C. S. Knight returned as agronomist of the station. H. H. Simpson resigned as animal husbandman of the New Mexico station and his duties were assumed by Luther Foster.

At the New York Cornell station R. A. Emerson, of Nebraska, was appointed in charge of plant breeding. At the Oklahoma station R. O. Baird and A. A. Jones, of the chemical department; C. I. Bray, assistant in animal husbandry; and E. I. Lichti, assistant entomologist, resigned. A. H. Leidigh was appointed agronomist in charge of soil improvement at the Texas station. In Utah C. N. Jensen was succeeded by G. R. Hill as plant pathologist of the station. At the Virginia station S. W. Fletcher, director; N. S. Mayo, animal husbandman; E. B. Fred, bacteriologist; W. K. Brainerd, dairyman; and Lyman Carrier, agronomist, resigned. At the Washington station P. J. White, agronomist; A. Carlyle, cerealist; R. Ashby, animal husbandman; and J. G. Hall, plant pathologist, resigned.

In West Virginia F. E. Bear was appointed in charge of soil investigations at the station and E. W. Sheets in charge of animal husbandry. Dr. S. M. Babcock, of the Wisconsin station, retired after 25 years of active service, and Dr. F. W. Woll resigned to take charge of animal nutrition in California. In Wyoming Dr. L. D. Swingle, bacteriologist, resigned and was succeeded by Dr. J. W. Scott.

#### SUBSTATIONS AND DEMONSTRATION FARMS.

Additions to the number and area of substations and demonstration farms during the fiscal year 1914 were less numerous than in previous years. Many of the stations have already acquired suitable areas for substations in different parts of the State, where the results obtained from laboratory investigations may be subjected to a critical test and where long-time experiments, involving a study of the principles of soil fertility, the rotation of crops, the effect upon the following of the preceding crop, and long-continued fertilizer experiments, may be

conducted under satisfactory conditions. In other cases such facilities for local experiments have been provided by lease or by arrangement with farmers or institutions.

While the substations have often proved helpful in the experimental work of the station, their limitations are quite apparent, and the overhead charges make them a relatively heavy expense. Only a limited number of substations can be administered by a station in such a manner as to keep a strict control of results and to make the work fit into or satisfactorily supplement the studies of the central station. Without supervision by the specialists of the central station and help from its laboratories, the substation remains a weak institution from the standpoint of real experimentation and is quite largely a farm for local demonstrations.

The system adopted by the Texas station for the management of its 11 substations is one which practically obviates all danger of lack of control and inadequate supervision of the substation. The work at each of the Texas substations is an organic part of the work of the central station. The different members of the station staff exercise strict supervision over the work which comes within their field at the different substations. The various substations thus supplement the experiment-station farm, making it possible to carry on at the same time field and other experiments under different climatic conditions, and all coordinated by adequate centralized supervision.

The Indiana station received a bequest from a citizen of the State of 480 acres of land lying in two tracts near the town of Bedford. The smaller tract of 120 acres has upon it an 80-acre orchard, which, when put into good condition, will offer an excellent opportunity for experimental work in fruit growing and orchard management. The larger tract of 360 acres is well adapted to experimental work upon soil and field crops and will afford good facilities to the station for carrying on long-time experiments in these lines of investigations.

The Maine Legislature made an appropriation of \$10,000 for the purchase of a farm in Aroostook County, where much of the experimental work of the Maine station in potatoes and other field crops will be carried on.

The Maryland Legislature appropriated funds for the purchase of a farm at Ridgely which is to be used as a substation. This farm contains 50 acres and is well suited to general farming and to experiments with small fruits. A State appropriation of \$1,500 a year was made to maintain the substation.

In North Carolina substations are located at Rocky Mount, Statesville, Willard, Blantyre, and Swannanoa under support of State funds. A substation was also established at Oxford for use in experiments with tobacco and other crops.

In Ohio Washington County provided for a county experiment farm, and the State agricultural commission selected a tract of 170 acres near the town of Fleming and 10 acres near Marietta. This additional county farm brings the number of such farms under the supervision of the experiment station up to 15.

The State legislature in South Dakota provided a fund of \$3,000 for a demonstration farm at Vivian. This makes four substations in South Dakota supported by State funds and under the supervision of the State.

In Virginia an appropriation of \$21,250 was made by the State legislature for county experiment stations. This enables the station to continue tobacco investigations which had previously been carried on in cooperation with this department. The fund also made it possible to establish another substation at Holland for the study of crops grown in rotation with cotton and peanuts. The Virginia station now supervises eight substations at which the policy thus far has been to carry on experiments in determining the fertilizer requirements and rotation systems for the staple crops of each locality.

The Hawaii station carried on work of a cooperative nature during the year at the Waipio substation, where attention was chiefly devoted to a study of onion production under the dry-land conditions which prevail at Waipio.

#### STATION PUBLICATIONS.

On account of the increasing amount of scientific research carried on by the experiment stations, it has become necessary to give some attention to the nature and classes of station publications. With the differentiation now brought about between extension work and station work, there will no longer be occasion for the stations to publish bulletins containing merely compilations from known and current literature. The station publications thus naturally fall into three classes—the annual report, the general or popular bulletin, and the technical bulletin.

The annual report of the experiment station is a more important publication than is generally recognized. The possibility of improving the annual report as a means of conveying an adequate idea of the progress of station work has been realized at many of the stations. In some instances, however, it is still almost exclusively of an administrative nature, giving little conception of what the real work of the station during the year has been, while in other instances it is perhaps unnecessarily large and encumbered with so many details that few readers find time for its perusal. The annual report of the station gives an excellent opportunity for the director to take an account of stock at the end of the year and to present in a brief

but adequate manner the important and interesting achievements of the station as a whole during the year. An annual report thus conceived carries much of interest to a wide range of readers.

The publication of two series of bulletins, one of a popular and the other of a technical nature, has for several years been maintained at many of the stations and there are many good reasons for continuing such an arrangement, although the necessity for the publication of a strictly technical series of bulletins is partly relieved by the present tendency to publish purely technical matter in journals designed for circulation among the scientific workers.

It is obviously necessary in order to make a bulletin an effective vehicle for the idea in the mind of the writer that the interests of readers should be definitely considered during the writing of the bulletin. There has been a tendency in some cases to consider the supposed grade of intelligence of the reader rather than his interests. Agricultural science, however, if presented in a clear and logical manner, is by no means beyond the understanding of the average reader. Keen interest in the discovery of truth is almost a fundamental characteristic of human nature without regard to class or condition. The interest of the general public in reading adequate accounts of scientific discoveries may be almost, if not quite, as keen as the interest of the scientist in making these discoveries.

The difficulties experienced by the average reader in understanding scientific literature are not so much due to the natural complexity of science as to a lack of clearness in the statement of the case. Some of the classic accounts of scientific work are readily within the understanding of the average high-school pupil, and a source of intellectual pleasure and interest. If the presentation in bulletin form of the results of scientific investigations in agriculture fails to appeal to or awaken the interest of the general reader, the cause of this failure is to be sought in the manner of presentation rather than the nature of the subject.

In putting into written form the results of scientific investigation some things must be taken for granted; for example, that the investigator is essentially honest; that the facts which he presents are stated as he observed them, that the interpretation of the phenomena are in accordance with the best light which could be thrown upon the problem. It must also be taken for granted that the methods employed in making the investigation were scientific, precise, and were checked by all known means for avoiding errors. It is unnecessary, therefore, that the ordinary bulletin should be burdened with too many details of notes taken along the way. Occasionally a bulletin appears containing essentially every mark and notation of the notebooks used during the course of the investigation. Many such notes and detailed records are quite useless to the reader, since he did not go

through the investigation himself and is not in position to interpret the notes. The general reader is primarily interested in results rather than methods. Detailed accounts of methods and processes, however interesting they may be to the technical worker, can not be expected to appeal to the general reader.

The necessity for including details of technical methods, purely abstruse material, complex mathematical formulas, and other material of a strictly technical nature is largely removed by the possibility of publishing such material in technical journals for scientific readers. An increasing number of station workers are availing themselves of this opportunity and are thus relieving the station bulletins of material which can hardly be of general interest, and at the same time are calling the attention of the scientific world to the large amount of thoroughly scientific investigation which is being carried on at the stations.

The more technical investigation of the experiment stations, especially that conducted with the support of the Adams fund, yields in the aggregate a large number of technical papers which have been published in a wide range of scientific journals. This serves to bring the scientific work of the experiment station to the attention of the general scientific world, but it also has the effect of scattering the stations' publications and, in the case of the individual station, of taking them out of their series. Occasionally papers thus published carry no footnote or other indication as to their origin. It is highly desirable and proper that such papers be definitely connected with the station or laboratory from which they came and often with the project to which they relate.

With this widespread publication of station investigations it is difficult to keep track of it as a record of work performed, and this office has found it well-nigh impossible to obtain complete reference to such contributions outside the regular series. This outside publication of papers relating to the station work should naturally be under control of the director, and it is highly desirable that each station collect and file a complete set of such publications in order to preserve a full record of its published work. It would be well also if a list of these papers, with brief notes if necessary, were printed in the annual report.

The number of station publications during 1914 was nearly double that issued in 1913, and the volume increased about 3,000 pages over that of the previous year. More than one-half of the volume of this published material was occupied with progress reports and the finished results of experiments and research. In order to make the statement of these results more readable and in order to appeal to a larger circle of readers numerous popular bulletins and circulars were prepared.

The number and importance of technical bulletins showed a further increase. In some cases these bulletins were of purely technical nature, stated in such phraseology as to carry an appeal chiefly to scientific workers. In other cases the abstruse matter, complex mathematical formulas, and the other machinery of technical phraseology were avoided, while the essentials of the matter were so stated as immediately to interest the farmer and general public.

The station publications as a whole furnish an increasingly important contribution to the understanding of agricultural problems. The whole field of agriculture in all its parts is covered by these publications. A larger number of bulletins than in any previous year dealt in a serious manner with the problems of rural economics. The regular bulletins of the station show a closer approach to that happy combination of the scientific and practical in which the precise and searching methods of investigation are applied to the difficulties which confront the farmer.

### SOME RESULTS OF STATION WORK.

The operations of the experiment stations in the various States covered a wide range of scientific investigation and practical experiment. Much of this work necessarily dealt with the multifarious details of inspection and control and related lines of service distinguished from experimental and research work. An increasing proportion of the station work, however, is investigation of fundamental and highly important nature. These investigations cover the whole field of scientific agriculture.

Some of the results of this investigation are brought together in the following paragraphs in order to give some hint of the important accomplishments of agricultural research at the stations during the fiscal year. Investigations along the same lines have in many instances verified one another and have tended to establish firmly certain principles of wide application. In other cases divergences in results have indicated the necessity of further research in some of the difficult lines of agricultural study.

#### AGRONOMIC INVESTIGATIONS.

For many years experiments have been carried on to determine the possibility of the improvement of wheat by pure-line breeding and by hybridization. As a result of five years' work at the Ohio station little encouragement was found for the continuation of efforts to fix either a high or low content of protein in wheat, or the weight of the grain, the length of the head, or the size of the kernel. Similarly the results of line-selection work at the Washington station indicated clearly that high or low nitrogen content is not a property of wheat

which can be fixed by line selection. The chemical composition of wheat appeared to be entirely a matter of environmental influence and not a hereditary character. This work had been carried on for seven years and the conclusion was reached that further attempts to improve the composition of wheats by line-selection breeding are futile. It was held, however, that the possibility still remains open that inheritable changes in the chemical composition may be brought about by hybridization.

At the California station the influences which affect the protein content of wheat were investigated, and the findings indicated that there are seasonal and varietal variations in the protein content, and that the amount of protein may be considerably affected by climate, particularly the amount of moisture in the soil. Under controlled laboratory conditions it was found that the protein content may be increased by retarding the growth of wheat by lower temperatures.

The Kansas station studied the influence of a number of substances upon the baking qualities of flour. The chemicals added to flours in these experiments included peptones, glycocoll, leucin, aspartic acid, asparagin, acetate, tartrate, chlorid, and phosphate of ammonium. No marked or uniform effect was produced by these substances upon the first rise in making bread from the flour. As a rule, the amino compounds tended to decrease the maximum volume of the dough and had no unfavorable effect upon the texture of the bread. It appeared that the baking qualities of flour depend upon other influences, as well as upon the relation of gliadin and glutenin, and bear an intimate relation to chemical substances which may naturally be present or which may be produced from normal constituents of the flour.

A study of the phosphorus content of flour in its relation to baking qualities was made at the North Dakota station, with the result that the larger loaves were found to contain less of all the different forms of phosphorus than the smaller loaves. The influence of an acid extract of wheat bran upon the dough was shown in an increase of from 6 to 20 per cent in the volume of the loaves and a better color and texture of the bread. In general, the higher the gluten content of flour the more marked was the improvement brought about by the use of the acid extract of bran.

At the Illinois station, in addition to the long-continued breeding experiments with corn to obtain strains high and low in protein and oil, to modify the height at which the ear is borne, and the angle at which the ear is attached to the stalk, another line of investigation was concerned with the test of seed from the first-generation hybrid as compared with that of the pure-bred parent. In varieties which were closely inbred a distinct benefit was noted from hybridization;

on the other hand, no benefit was observed from crossing commercial varieties. At the Maine station the fourth year of careful selection of one variety of corn brought forth a marked improvement in earliness and vigor. In general, however, breeding and selection work with corn showed that it was impossible to change the inherited constitution of corn by the ear-to-row method of breeding, but that a certain amount of adjustment to local environment was secured.

Inheritance of pigments in corn was investigated at the Nebraska station. The variation in color was found to be connected with a dark-red pigment in the pericarp of the corn kernels. Experiments indicated that the more color there was in the pericarp of the seeds the more likely they were to produce plants with wholly self-red ears and the less likely to produce plants with variegated ears. The chemical composition of corn at different stages of growth was studied at the Indiana station. In these experiments it was found that all chemical ingredients increased up to October 1. After the formation of the ear began the dry matter, crude fiber, fat, and carbohydrates in the stalks, blades, and husks remained practically constant, while all these ingredients increased in the ear. The period of greatest starch formation fell between September 24 and October 1. When corn was supplied with irrigation water at regular intervals the plant took up 35 per cent more nitrogen and twice as much potash as was commonly the case.

In a study of the effect of varying quantities of water on the growth of corn at the Utah station it appeared that the highest yield of corn was produced where 15 to 30 inches of water were applied. In a study of the results obtained it was considered that 20 inches was about the most effective quantity of water to use. A diminution in yield appeared where 40 inches of water were applied. Large amounts of water caused a decrease in the size of the grain, cobs, and leaves, and an increase in the husks and stalks. The time of maturity of corn was delayed by irrigation. The number of stomata on the leaf surface was increased by large amounts of irrigation water.

Hybrids between Lyon and velvet beans were studied at the Florida station. In this work the interesting discovery was made that semi-sterility may occur in the hybrids and may become an inherited character. The abortion of half of the pollen grains and half of the embryo sacs appeared to be due to a segregation of the Mendelian factors. In some of the hybrids between the Lyon and velvet beans a definite increase was obtained in earliness and yield. Apparently also a Mendelian factor was found to determine the length of the pods.

The effect of certain crops upon the growth of following crops was made the subject of an extensive inquiry at the Rhode Island station.

This work has been going on for several years. The results thus far obtained indicate that the effect of crops on succeeding ones is not limited to a modification of the supply of plant food, but appears to include variable factors which act differently on different plants. Onions were found to be exceedingly sensitive to soil acidity and to be greatly reduced in yield by a previous crop of buckwheat. Depending on the crop which preceded onions, the yield of onions varied from 12 to 400 bushels per acre. A variation of from 4 to 35 bushels per acre in buckwheat was noted in different rotations, the crop being almost uniformly poor when following clover. Likewise at the Virginia truck station the yield of kale was found to vary according to the crop or rotation of crops which preceded it. The largest yield was obtained following crimson clover with lime, while the smallest yield of kale occurred following potatoes and corn.

Interesting information concerning the fertility and feeding value of flax and flax products was obtained at the North Dakota station. It was found that flax contains far more fertility than the ordinary grain crops. On the basis of this finding it was recommended that all flax products be carefully saved on the farm to be returned to the soil. Flax straws and other coarse by-products of flax were shown to be richer in protein than other straws, occupying a position between grain straws and legume hays, and therefore being of rather high feeding value.

In a study of the frictional resistance in artificial waterways the Colorado station found that the multiple-point method, whereby the velocity is obtained by holding the current meter successively at points relatively close together in a vertical plane, gave the closest determination of the mean velocity. A much more rapid but less reliable method of determining the velocity of the water was found by assuming the average velocity of all the water in the waterway to be represented by the velocity found at 0.6 of the depth from the surface.

During an investigation of the chemical changes in silage at the Iowa station it was found that nonreducing sugar was rapidly changed to reducing sugar, and that the latter decreased in amount but did not disappear completely. The amount of volatile acids increased from day to day. Lactic acid showed an increase in all kinds of silos. Alcohol was formed in small amounts and carbon dioxid developed rapidly after the silo was filled. Free oxygen disappeared entirely after the second or third day.

#### ANIMAL HUSBANDRY.

Gratifying diminution was noted in the number of simple commercial feeding experiments such as have been carried on in years past at many of the stations by way of comparing the results from

different combinations of ordinary feeding stuffs to note the rate of growth in animals and the percentage of dressed weight. During the year a large amount of work of a far more fundamental nature was done, and much of this resulted in establishing underlying principles of great importance and wide application. At the Illinois station, in digestibility experiments with steers, it appeared that the coefficients of digestibility of the dry substance and carbohydrates of a ration composed of clover hay and ground corn in equal parts varied inversely as the amounts of feed consumed throughout the variations in amounts of feed from maintenance to a full ration. The coefficients of digestibility of dry substances and carbohydrates of a ration composed of clover hay and ground corn in the ratio of 1 to 3 or 1 to 5 were sometimes greater in the maintenance ration than in any other ration up to that of full feed. The coefficients of digestibility of neither protein, fat, nor any other single constituent of the ration was apparently affected by the amounts of feed consumed.

At the Pennsylvania Institute of Animal Nutrition a greater refinement of methods was obtained in determining the heat production from rations fed to steers in the respiration calorimeter. The difference between the computed heat of the ration and the observed heat production was only four-tenths of 1 per cent. Thus was confirmed by direct experiment the well-known law of the conservation of energy, and direct evidence was obtained that the heat in the animal body arises exclusively from the combustion of food in the body.

As a result of experiments with steers on a continuous ration of corn silage at the Georgia station it was found that when an animal is placed on a low plane of nutrition it does not more completely digest the feed during the progress of the experiment, but that the tendency seemed to be somewhat in the opposite direction. The digestibility of the feed was somewhat retarded after an animal had been held on a low plane of nutrition for some time. This was interpreted as meaning a general retardation of the digestive functions. Apparently the maintenance ration of steers did not decrease during the progress of the experiment through the ability of the animal to take more of the nutrients from the feed, but rather as a result of the more economical use of the feed consumed.

Range steers varying in age from calves to 3-year-olds were fed at the New Mexico station for 120 days on alfalfa hay alone. At the end of this period satisfactory results as to condition were observed, although not all of the animals showed the highest finish. The amount of feed consumed daily per hundred pounds of live weight was 24.44 pounds with calves, 23.29 with yearlings, 23.51 with 2-year-olds, and 18.43 with 3-year-olds. The amount of feed consumed per pound of gain was 7.77 with calves, 11.11 with yearlings, 11.46 with 2-year-olds,

and 20.43 with 3-year-olds. In chemical analyses of meat samples obtained from the animals in these experiments, the results agreed with observations in regard to the visible fat in so far as the corresponding cuts of meat were relatively richer in fat in the older steers.

At the Pennsylvania Institute of Animal Nutrition a study was made of the influence of the standing or lying position upon metabolism in cattle. It was determined that the mere act of standing increased the amount of radiated heat from 34 to 39 per cent, the excretion of carbon dioxid from 28 to 30 per cent, and the excretion of water vapor from 31 to 33 per cent. The increased radiation of heat while the animals were standing was thus accompanied by correspondingly increased elimination of both carbon dioxid and water. It was concluded from these experiments that the increased heat emission while standing represented substantially the increase in heat production during the same time.

In hog feeding experiments of the Kansas station it appeared that feeding corn alone in dry lot did not give satisfactory results. A ration of corn and alfalfa hay proved to be much more economical; in fact, supplementing the ration with any suitable nitrogenous feed increased the efficiency of the ration and the rate of gain. Parallel experiments showed that hogs on pasture made cheaper and more rapid gains than in dry lot.

At the Illinois station it was found that variations in the amount of protein of from 0.32 to 0.94 pound per hundred pounds of live weight of growing pigs did not affect the nature of the nitrogenous material produced during growth. It was concluded that while slight variations may result from differences in the amount of protein consumed, it is more probable that variations in the composition of the nitrogenous constituents are due to influences inherent in the animal itself and independent of the character of the feed. When the supply of protein in the ration was deficient either quantitatively or qualitatively the amount of the body protein was affected while the character of the body protein remained unchanged.

A study of the phosphorus of growing pigs at the Illinois station showed that the total phosphorus in the bodies of pigs 40 to 43 weeks of age is distributed as follows: Four-fifths in the skeleton, one-ninth in the meat, and one-twentieth in the offal. The water-soluble phosphorus was found to constitute seven-tenths of the total phosphorus in meat and two-thirds of that in the offal. During the period of growth from 51 pounds to 191 pounds live weight the percentage of phosphorus in the skeleton was increased one-half and that in the entire body about three-twentieths.

Experiments at the Ohio station in the nutrition of pigs showed conclusively the unsatisfactory character of corn, wheat middlings, linseed meal, soy beans, wheat bran, and rice polish as sources of

lime for growing pigs. Rations composed of these feeds did not maintain normal growth of bone. Growing pigs stored up nine or ten times as much lime from rations containing meat and milk meal as from the best rations of corn alone. The important deficiencies of corn from a nutritive standpoint were shown to be calcium, phosphorus, and nitrogen. In the whole series of experiments the rations all contained an excess of acid over basic mineral elements, but this excess of acidity did not appear to affect the retention of lime.

At the Wisconsin station it was shown that the addition of carbonate or phosphate of calcium to grain rations for growing pigs resulted in an increased retention of both lime and phosphorus and the formation of a heavier skeleton. The relative efficiency of carbonate and phosphate of calcium in increasing the retention of phosphorus appeared to depend upon the amount of phosphorus present in the grain. The addition of calcium to rations for growing pigs increased the size of the shaft of the bone, but did not affect the length or rate of growth of the bone.

A number of interesting points were brought out during the year in experiments with cottonseed meal. At the Texas station cottonseed meal was made into products for use as human food, and a number of digestion experiments were carried on with these products. The digestibility of the protein of cottonseed meal was found to be 77.6 per cent, as compared with 96.6 per cent for the protein of meat. The digestibility of the fat of cottonseed meal proved to be very high. In these experiments the body requirement for protein was met by a daily ration of 2 ounces of cottonseed meal, one-half gallon of milk, and 8 ounces corn meal.

Cottonseed meal was fed to rabbits and hogs in experiments at the Louisiana station for the purpose of learning something more definite about the toxicity of cottonseed products. Sterilized cottonseed meal fed in liberal amounts for 100 days apparently had no injurious effect. Considerable variation in the toxicity of cottonseed was noted in seed from different soils.

At the North Carolina station satisfactory results were obtained in preventing the poisonous effect of cottonseed meal by feeding daily about one-third ounce of iron chlorid or copperas per hundred pounds of live weight of hogs. Ashes fed in liberal amounts also had a beneficial effect. Pigs fed from May 28 to November 4 remained in perfect condition, although they received 1 pound of cottonseed meal daily per hundred pounds live weight. At the Oklahoma station it was found that within reasonable limits cottonseed meal had no apparent effect on the fertility in poultry and hogs so long as the animals remained in good health. The principal organic phosphoric acids of cottonseed meal were separated, purified, and analyzed in the form of silver salts at the Texas station. The organic phosphorus com-

pounds of cottonseed meal were found to yield inosite. At the South Carolina station cottonseed meal was fed to cows in rations as high as 6 pounds a day without deleterious effects. Striking differences were noted in the toxicity of different samples of cottonseed meal for pigs, but no sample proved decidedly toxic.

The nutritive deficiencies of the proteins of corn and wheat and of certain oils were studied at the Connecticut State station. The deficiencies in the proteins were shown to be due to their lack of certain amino acids. The addition of these amino acids to the defective diet rendered them adequate for maintaining animals and producing growth. It was also found that when lard, olive oil, or almond oil constituted the sole fat in the diet of rats growth ceased after 80 to 100 days. Growth was again stimulated, however, by replacing some of these fats in the diet by butter fat. Nutrition experiments with rats at the Wisconsin station on a diet of casein, dextrin, and inorganic salts showed that on this ration the animal soon altogether ceased to grow. A new growth stimulus was produced, however, by adding to the ration small amounts of the ether extract of butter or of eggs. These products, known as lipins, are believed to be of great importance in nutrition, and were obtained from boiled as well as from raw eggs.

The effect of close inbreeding in cattle, pigs, and sheep was studied at the Delaware station. It was found practically impossible to carry on breeding experiments further when the animals contained more than 75 per cent of the same blood. This degree of inbreeding was obtained in the fifth generation. No harmful effects were observed from inbreeding hogs up to the extent of 75 per cent of one strain of blood, but a check on further inbreeding appeared in the fact of increase of sterility. Inbreeding was carried on with Guernsey cattle until the animals contained 60 per cent of the same blood.

#### POULTRY INVESTIGATIONS.

The investigations of the stations on poultry brought out many results of general interest. A study of the constitution of the White Leghorn breed at the Rhode Island station involved crosses between this breed and a number of black breeds, during which it was found that the barring of the plumage did not arise as a result of crossing, but had its origin in a factor for barring present in one of the parents. It was concluded, therefore, that a barring character can not be produced or synthetized from breeds not possessing the factor for barring. At the Cornell station it was found that the selection of fowls for strong vitality, even if this selection be exercised only once, increases the productive power of a flock. One selection was held, however, not to be sufficient to keep a flock permanently superior. The selection of mature pullets appeared to be of more value

for this purpose than of partly grown chickens, and selection at the beginning of the second year seemed to be of equal importance with selection during the first year.

At the Maine station an investigation was made of the factors which influence the size, shape, and constitution of the egg of fowls. It was found that hens which lay large eggs lay eggs with a small proportion of yolk. The eggs of an individual hen tended to be either uniform or variable in all of the egg characters. An individual hen in respect to egg characters was found to be less variable than the race. The weight of the egg and of the different parts of the egg, especially of the yolk, increased with the increase in age of the hen.

At the West Virginia station the average weight of eggs was found to vary from month to month, reaching the maximum in early spring, when the fowls are laying most heavily. White Leghorn eggs did not reach their maximum weight until the hens were in the third laying season. Low rations reduced and heavy rations increased the size of the eggs. Moreover, deficient rations were found to lower the hatching power of the eggs.

The variation in egg yields was investigated at the Utah station, records being kept continuously on a number of flocks for several years. Contrary to the accepted opinion of the necessity of frequent renewal of flocks in order to obtain highest egg yield, it was found that nearly all of the long-lived hens of a well-selected flock will lay over 500 eggs, some of them giving records as high as 800 or more. More hens made their highest year's record after the first year than during the first year. Nearly all the hens which gave an extremely high total yield of eggs during the several years of observation made only low or medium records during the first year. The average productive life of the strain of fowls in this experiment appeared to be about four years.

A study of the bacterial content of eggs as related to their keeping qualities was carried on at the Kansas station. It appeared that nearly all eggs containing bacteria were infected in the yolk, while few of them showed bacteria in the white. The number of infected eggs increased only slightly with the age of the fowls. Eggs from the same hen were found to vary widely in bacterial content and keeping quality at different times and without any known cause. Fowls which were allowed to range at large showed a smaller percentage of infected eggs.

The Storrs station investigated the relation of carbon dioxid in incubators to the hatching of eggs. The chief source of carbon dioxid in incubation was found to be in the embryo; the amount of carbon dioxid under sitting hens was shown to be much higher than

that of the room and to increase up to 50 or 60 parts per 10,000. In all of the commercial incubators under test, the amount of carbon dioxid increased during the period of incubation from a little more than that in the room air to a total of 30 to 50 parts per 10,000. The presence of such quantities of carbon dioxid, however, had no deleterious effect upon the hatching of the eggs. In fact, the effect of carbon dioxid was slight until the amount reached 150 parts per 10,000.

In a comparison of protein from vegetable and animal sources in rations for chickens at the New Jersey station, it appeared that protein from a vegetable source, even when accompanied by a high phosphoric-acid content, was not efficient for growing chickens or laying fowls. The addition of animal protein greatly increased the efficiency of a ration relatively high in vegetable protein. Phosphoric acid from animal bone was shown to be far more efficient than that from inorganic sources. Incidentally, it appeared that lime from bone was not as easily assimilated as lime from phosphate rock.

In continuation of a long series of experiments on nitrogenous feeds for chickens the Rhode Island station investigated the use of cottonseed meal for this purpose. Extracts made from cottonseed meal were shown to have no harmful effect upon rabbits or hens, and no toxic condition resulted from feeding cottonseed meal in relatively large rations. For the best growth of young chickens it was shown to be more important that the amount of protein be sufficient than that it be associated with a definite proportion of carbohydrates and fats. The conclusion was reached that if the constituents of bone are otherwise supplied in the ration, cottonseed meal may well be used to furnish a considerable portion of the protein required for chicks. Similarly, at the Mississippi station, it was found that cottonseed meal used as the chief source of protein in rations for hens was palatable and efficient in egg production. The general condition of hens fed on cottonseed meal remained as good as those fed on beef scrap.

Several of the New England stations devoted much energy to a study of poultry diseases, particularly white diarrhea and fowl cholera. At the Storrs station it was found that female chicks affected with *Bacillus pullorum* at an early age may develop into permanent carriers of the disease and may be a constant source of further infection. In some cases 25 per cent of an infected flock may become permanent carriers. The gross agglutination test gave results which indicated that this method is an important aid in the recognition of white diarrhea in laying hens. Sour milk proved to have a beneficial influence on the growth of chicks and to lessen

mortality from other causes as well as to some extent from white diarrhea. For this purpose naturally soured milk was as efficient as that soured by *B. bulgaricus*.

Similarly, at the Massachusetts station, the macroscopic agglutination test proved an excellent laboratory method for the detection of infected fowls. Rabbits inoculated with pure cultures of the bacillus of white diarrhea yielded active agglutinin and also bacteriolytic sera which may possibly be used later in immunizing fowls. At the Rhode Island station rabbits were used in laboratory experiments in testing the possibility of producing immunity to fowl cholera. It was found that female rabbits immunized with inoculations of a nonvirulent culture of fowl cholera transmitted a high degree of resistance to virulent cultures in the offspring. Some immunized mother rabbits produced immune offspring for two or three years after immunization. The resistance in the offspring was not permanent, however, enduring for not more than 40 days.

#### DAIRYING.

In a study of milk production at the Minnesota station it was found that with cows averaging 910 pounds in weight the nutriment consumed averaged 15.47 pounds daily. After deducting the nutriment calculated for maintenance of the body an average of 8.27 pounds per day was left for milk production. In these experiments the average amount of feed required for a pound of milk was 1.83 pounds. While the possibility of affecting the composition of milk by the feed appeared to be somewhat doubtful, it was noted that as the milk increased in fat content it also increased in protein content but at a slower rate.

At the New York State station a careful study was made of the cells which occur in milk. These cells were found to be chiefly leucocytes. The largest number of cells was found in colostral milk but the number varied greatly in the normal milk at any stage of lactation, in some cases reaching as high a count as 1,000,000 per cubic centimeter. No relationship was demonstrated between the number of cells in the milk and specific bacterial troubles of the udder.

In studying the effect of certain dairy operations upon the germ content of milk, the same station found that the cleanliness of the interior of the stable within a fairly wide range had no measurable effect upon the milk. This finding is considered of great importance from the standpoint of economy in the production of sanitary milk, and makes it necessary to examine all of the dairy operations, one at a time, in order to determine the chief sources of bacterial contamination. It was found easily possible, even in a very dusty stable, to obtain milk with less than 1,000 bacteria per cubic centimeter.

An elaborate investigation of the yellow pigment in milk at the Missouri station showed that the yellow color of milk is due to carotin and xanthophyll, that these coloring matters are taken up from the feed and are not synthesized in the body; and that the same pigments are the basis of the yellow color in the body fat. The yellow pigment of milk whey, however, was found to be lactochrome. At the Missouri station a study was also made of the influence of rations upon the fat content of milk. Underfeeding was found to affect not only the percentage of fat but its composition, and the influence of underfeeding appeared to be greater than changes in the kind of feed.

A comparison of the value of alfalfa and corn protein in the production of milk casein was made at the Wisconsin station. For this purpose alfalfa was found to be as effective as corn. The amino nitrogen proved to have nutritive value, but no indication was found of the value of acid amid nitrogen. In these experiments alfalfa hay was observed to have a specific diuretic effect.

On account of great differences in the digestibility of raw untreated milk from different cows as food for infants, the Maryland station made an elaborate study of the curd as an index to the food value of the milk. By a study of the reactions of milk protein in the presence of precipitating solutions, it was found that the milk protein of Holstein and Ayrshire cows was more decidedly flocculated than that of Jersey and Guernsey breeds, and therefore was not so easily curdled with the natural acid of the stomach as was the milk of Jersey and Guernsey cows.

The effect of alkali water on cows was studied at the South Dakota station. Alkali water did not produce what is commonly called the alkali disease, although at first it exercised a laxative effect upon the cows. Some of the animals used in the experiment were killed and examined without revealing any abnormal conditions. The principal mineral in the alkali water of this experiment was sodium sulphate and about three-fourths of this salt was eliminated through the kidneys.

#### RURAL ECONOMY.

Within recent years the study of the economic aspects of farming by the stations has been prosecuted actively to a greater extent than formerly from the standpoint of the economist. At the Montana station it was found that the average farm was too small to be operated with greatest profit to the owners. The most profitable farms were at least 25 per cent larger than the least profitable ones. Grain crops combined with stock appeared to be much more profitable than either grain or stock alone. The more successful farms were much more diversified than the less successful. There was an average difference

in yield of 22 per cent in favor of the successful farms as compared with unsuccessful ones.

At the Cornell station it was found that while present conditions indicate the possibility of bringing more land under cultivation and of increasing yields of land now tilled, no increase in acre yield was possible without increased cost. The law of diminishing returns was found to apply in farming, as in other lines of business, so that each additional bushel of yield, above a good average, was obtained at an increased cost. The possibility of reducing the cost of living appeared to lie more in a better system of distributing the products than in obtaining greater yields.

The West Virginia station made a study of the business aspects of market gardening in the Ohio and Kanawha Valleys, in which it appeared that the returns from truck crops were much greater than those from ordinary farm crops, that the present development of the industry of market gardening was less than might be accomplished with profit, and that the chief hindrance to the development of the industry in the valleys in question was the lack of suitable farmers.

The Hawaii station organized a farmers' market in Honolulu, the chief city of the Territory, for the purpose of furthering the distribution of miscellaneous farm products. The response shown by farmers to this movement indicated clearly that the trouble previously incurred along this line was due almost entirely to the difficulty in distributing products experienced by small farmers, with their usual lack of cooperative organization. The handling of miscellaneous small consignments from various parts of the Territory in one central market made it possible to serve the buyers in such a manner as greatly to stimulate the demand for local produce and thus to encourage the further development of diversified agriculture.

The labor cost of producing corn was made the subject of a systematic study at the Ohio station. At the usual price for horse labor and man labor it appeared that the cost of producing corn ranged from \$9.62 to \$22.01 in different parts of the State. In some instances the crop yield was not sufficient to pay for the single item of labor unless the labor could be obtained at an extremely low rate. In general, the labor cost per acre was less on large fields than on small ones. The cost of harvesting the corn was one-third of the total labor cost. Considerable economy was found, therefore, in more horse labor in cultivation and, where possible, in harvesting by live stock.

A study of 10 years' profits from an apple orchard by the New York State station showed a net profit for this period of \$1.31 per barrel for apples of first and second grade, or a profit of \$120.60 per

acre. These figures were obtained in a Baldwin orchard in its fourth decade. The profits from this orchard were believed to be many times as great as those from the average New York orchard.

#### ENTOMOLOGICAL INVESTIGATIONS.

Among the numerous entomological investigations at the stations a few results may be selected which are perhaps of particular interest. A systematic study of methods of destroying insects in mills and stored grain at the Kansas station showed clearly that while many insects did not yield readily to hydrocyanic-acid gas, no insect pest of flour mills could withstand for any long time a temperature of 118° to 122° F. This temperature maintained for 24 hours not only destroyed the insect pests effectively but caused no injury to the mill, its equipment, or contents, and caused no particular liability to fire.

At the Alabama station considerable attention was given to the attacks of rice weevil upon stored corn. The common practice of storing corn without husking was condemned for the reason that when stored in this manner corn is much more susceptible to the attacks of rice weevil. The station therefore recommended as a result of its experiments that in practice the rice weevil as a stored-corn pest can be best controlled by husking the corn before storing and by fumigation with carbon bisulphid later if this treatment should be found necessary. In corn stored with the husk on, an average of 43 weevils per ear was found, as compared with 10 weevils per ear in husked corn.

The study of the woolly aphis of the apple at the Maine station led to some new information of unusual interest regarding the life history of this pest. It appeared that the elm is the primary host of the woolly aphis of the apple, and that the eggs of the woolly aphis may be found under the bark of the elm during the winter. From these eggs two generations of wingless females appear on the elm, followed by a third generation which migrates to the apple and which produces two more wingless generations, after which migration takes place in the fall to the elm. This discovery furnishes a clue to the great difficulty which has been experienced in keeping apple nurseries free from woolly aphis. On the basis of the findings made at the Maine station, it was recommended that nurseries be established at a safe distance from elms or that neighboring elm trees be destroyed.

A study of the sugar-beet root louse at the Montana station also brought out some interesting results regarding the life history of this pest. It appeared that wingless female lice were found upon the roots of sugar beets and weeds throughout the year; that winged

individuals were produced in the fall and migrated to cottonwood trees, on which each female deposited a single winter egg in the crevices of the bark. The young lice hatching from these eggs form galls upon the cottonwood tree, in which a single generation is produced, which become summer migrants and fly away to beets and weeds.

The life history of the sheep tick was carefully worked out at the Wyoming station. It was found that the fertilized egg passed through most of the larval stage within the body of the female, and that pupation took place 12 hours after the egg was laid. The life period of the pupæ was from 9 to 45 days, according to the prevailing temperature, and the time required for the females to reach maturity after emerging ranged from 14 to 30 days. The whole life of the tick was found to be spent on the sheep, and it was noted that the ticks could not live more than two days when removed from the sheep.

The chemistry of lime-sulphur solutions was subjected to a thorough study at the Delaware station. As a result of this work, it appeared that lime-sulphur solutions consist principally of pentasulphid and thiosulphate of calcium, and that when the ratio of lime to sulphur is 1 to 2.25 the solution consists of pure pentasulphid and thiosulphate of calcium. In long-continued boiling lime-sulphur was found to be decomposed completely, with the formation of hydrogen sulphid, calcium sulphite, calcium thiosulphate, and free sulphur. The presence of magnesia was found to be without effect in the making of lime-sulphur solutions, and self-boiled lime-sulphur solutions appeared to differ from the concentrated preparations in containing large quantities of free lime.

Since it has been found impossible to secure a mating of bees in confinement, many attempts have been made at artificial fertilization of queens in order that the results of breeding may be more closely controlled. At the Minnesota station artificial fertilization of queens was found to be a very difficult process on account of the danger of injuring the queen, and particularly on account of the tendency of the workers not to accept the queens which had been artificially fertilized. Success was had in one case only. Similarly, at the Hawaii station, after repeated attempts at artificial fertilization, success was had with one queen, which laid about 3,000 worker eggs, after which she began laying drone eggs. Apparently fertilization was not as complete as occurs under natural conditions. At the Texas station a location was selected far removed from any other bees, where it is hoped that breeding may be carried on without danger of miscellaneous crossing from unknown drones.

**HORTICULTURAL INVESTIGATIONS.**

From the numerous horticultural investigations of the stations during the year only a few can be selected for present purposes. A thorough study of tillage versus sod mulch at the New York State station showed that the disadvantages of sod in orchard were a lowering of the water supply, diminution in plant food, a reduction in humus and air supply, a lowering of the temperature, and harmful effects upon the soil bacteria. While the average cost of growing and harvesting an acre of apples was less under sod than under tillage, the production under tillage was so much greater as to show a balance of \$66.36 per acre in favor of tillage. The only locations in which sod mulch was found possibly desirable were on steep slopes where drainage was good and where danger from erosion was unusually great. Similarly at the New Hampshire station a comparison of various methods of treatment and tillage with sod mulch showed all other methods to be superior to the sod method in apple orchards.

In the study of pollination of sweet cherries at the Oregon station, it appeared that all varieties of sweet cherry were self-sterile, the self-sterility being in no case due to a lack of germinating power of the pollen, but to certain other physiological factors. Certain varieties were found to be intersterile, in which case mixed plantings would not set fruit. Certain varieties were found to be exceptionally good pollenizers toward other varieties. Intersterility of sweet cherry varieties was found to be apparently not correlated with their closeness of relationship.

In connection with the chemical study of citrus fruits, the Florida station made analyses of over 500 lots of oranges and grapefruit, extending through the whole season. The results indicated a gradual increase of total sugars as the oranges matured and a gradual decrease of acidity. Apparently all the acid of the fruit was formed early in the season while the sugar continued to be formed until maturity. In oranges sucrose and reducing sugars increased at about the same rate. Similar results were obtained with grapefruit. At the Delaware station an investigation of the composition of fruit juice indicated that the average molecular weight of the solids of fruit juice increased toward the time of maturing. Except in the case of the strawberry, the osmotic pressure of the fruit juice increased up to the final stages of ripeness.

An important discovery was made at the Oklahoma station in a study of the causes of the failure of the setting of fruit on the tomato. This trouble had been investigated for some time and had been ascribed to various causes. It was ultimately found that a minute insect, *Thrips tritici*, was feeding upon the pollen to such an extent as to bring about almost complete sterility. The varieties of tomato

which produced the largest amount of pollen naturally suffered least from the attacks of the thrips. While it may not prove an easy matter to control the pest, the knowledge of the cause of sterility of tomatoes in Oklahoma will give a specific direction to the efforts to overcome the trouble.

Among the many studies made on frost resistance and killing temperatures for fruits the investigations of the Missouri station are perhaps of special interest. It was found that the killing temperature of plant tissue was considerably lower whenever the sap density of the tissue had been increased. Rapid wilting of tissue did not generally increase the resistance of plants to low temperature. Tissue with a wet surface was found to suffer worse than dry tissue. Slow wilting through a long period increased the resistance of the trees to low temperature. The killing temperature of peach blossoms when the tree was just coming into full bloom ranged from 22° to 26° F.

The advantages which accrue from the use of large and heavy seed were studied at the Vermont station. The effects observed were a greater weight in Hubbard squash and pumpkin, an increase in edible material in lettuce, a larger width and number of leaves in spinach, and larger and earlier foliage in the case of parsley. One interesting result of experiments at the Alaska stations was the determination of the fact that a good quality of turnip seed can be grown at Fairbanks as well as at Rampart, and that this may possibly lead to the development of a considerable industry in the production of a high-grade turnip seed.

The rest period in potato tubers was made the subject of an elaborate study at the Maryland station. The carbohydrate transformation during the rest period was found to depend entirely upon changing temperature. No change was observed during the rest period in the relative amounts of the various forms of nitrogenous bodies. It was found that potatoes may be started at any time during the rest period by removing the skins and supplying the tubers with favorable growing conditions. The elimination of the rest period by this means did not appear to be due to the absorption of water.

#### INVESTIGATIONS OF PLANT DISEASES.

The study of the disease resistance of potatoes at the Vermont station showed that the varieties which possess the greatest resistance are for the most part of foreign origin and almost entirely without commercial value, and that therefore the practical value of disease-resistant varieties is very slight. None of the varieties of potatoes showed any strongly marked resistance to scab, although certain varieties were apparently somewhat less subject to the disease than others.

Cereal rusts received careful attention at the Minnesota station. It was found that the more resistant a type of wheat proved the more pronounced was the tendency of the rust to kill small areas of the leaf. The length of the incubation period of the rust was correlated to some extent with the degree of immunity, the most nearly immune forms of wheat showing the longer incubation period. On one of the most resistant varieties of wheat the spores of the rust were found to be small in size and sometimes aborted.

An elaborate study of wheat-sick soils at the North Dakota station showed that wheat does not thrive in the presence of its own dead material, however fertile the soil may be. Constant wheat cropping apparently did not particularly exhaust the soil from a plant-food standpoint or introduce substances toxic to the wheat. Constant wheat cropping, however, was found to introduce with the seed, stubble, and roots a number of fungi which cause a rot of the roots or blight, or otherwise destroy the plants. These fungus parasites appeared to accumulate in the soil and led ultimately to the condition known as wheat-sick soils. The condition was therefore considered not a problem of soil fertility but of disease, which should yield to proper methods of tillage and rotation.

Cedar rust was shown by the Virginia station to be one of the most serious fungus diseases of apples in that State. The time and amount of infection of the apple foliage was found to be largely dependent on climatic conditions, an alternation of rains and fair weather being most favorable for heavy infection. The apple leaf appeared to be susceptible to infection only during the early period of its development. Copper lime-sulphur spray proved to be exceedingly effective in checking the disease, but the destruction of all cedar trees within a half mile of the orchard was recommended as the surest way of preventing infection, and as a result of these studies legal provision for its control has been enacted.

Apple blotch, which has sometimes caused injury to 90 per cent of the fruit of susceptible varieties of apples, was studied at the Kansas station with reference to methods of control. The disease was found to yield readily to the application of Bordeaux mixture, and the interesting fact was brought out that by the continued use of Bordeaux mixture during successive seasons the disease can be practically eradicated from an orchard in from four to six years. Lime-sulphur solution for this purpose proved less effective than Bordeaux mixture.

In a study of nutrition as related to physiological diseases, particular attention was given by the Florida station to gummosis as produced by chemicals. In these experiments an enzym and 28 inorganic chemicals were injected into the trees for the purpose of deter-

mining their effect on the formation of gum. The most copious production of gum was caused by copper sulphate and other salts of heavy metals. After injection with these chemicals the injury extended from the point of injection to the stem or upper branches. Similar injuries caused by other chemicals did not extend much beyond the point of injection.

#### SOIL INVESTIGATIONS.

The investigation of soils during the year involved numerous interesting studies of the physics, chemistry, and bacteriology of soils. At the Nebraska station a study of the moisture conditions of soils on the North Platte substation showed that the maximum amount of moisture which these soils would hold under field conditions was 18 per cent and that the minimum point at which crops could obtain water was 7 per cent. Summer tillage was found to be the most efficient means of storing water in the soil. By this operation from 10 to 33 per cent of the rainfall was conserved. In cylinders 6 feet long and holding 100 pounds of soil, brought to the optimum degree of moisture, it was found that some plants would grow to maturity without the addition of water during the period of growth. In these experiments it appeared that the soil water available to plants was approximately equal to the free water or the difference between the total water and hygroscopic water of the soil.

At the New Mexico station a study of arid soils showed that the wilting point for corn on such soils was near 7 per cent of moisture, and that the hygroscopic moisture ranged from 1.1 to 5.1 per cent. The rate of penetration of moisture in sandy loam was determined as about 5 feet in 20 days.

The movement of salts in soils under the influence of irrigation water was also studied at the New Mexico station. It was shown that an application of water which would leach sodium chlorid down below 32 inches, at least to an extent tolerated by crops, did not carry sodium sulphate down below 2 inches in adobe soils. On sandy loam chlorids were leached by this treatment to a depth of 80 inches and sulphate of soda to a depth of 38 inches. The experiments indicated quite clearly that both carbonate and bicarbonate of soda were more easily leached from sandy loam and clay soils than sodium sulphate. The lowering of the tolerance limit to carbonates and bicarbonates, however, was believed to be due more to reactions with other salts than to the leaching effect of water.

The influence of soil moisture on the availability of plant nutrients was investigated at the New York Cornell station. In a series of experiments the percentage of moisture was varied and the effects of variation in moisture were shown principally on nitrates, which

disappeared almost entirely at the saturation point. The percentage of available potash and phosphoric acid, however, was little affected by the amount of moisture. Similarly, at the Washington station the position of nitrates in the soil was found to vary according to the moisture movements. In the early spring the nitrates were shown to have been leached down to the third foot of soil as a result of the winter rains.

In heavy clay soils all fertilizers were found, in investigations at the Hawaii station, to check the movement of soil moisture in all directions. Nitrate of soda increased the water-holding power of such soils. Lime and magnesium salts checked percolation in soils much less than salts of sodium, potassium, and ammonium. It was shown that phosphoric acid was fixed by Hawaiian soils to a much greater extent than other fertilizers.

The fate of magnesium carbonate in humid soils was studied at the Tennessee station and the conclusion was reached that magnesium carbonate does not exist as a solid mineral component of soils of humid climates on account of the rapid decomposition which it undergoes. The activities of humid soils appeared to result in the decomposition of magnesium carbonate even under decidedly calcareous conditions and without drainage. Magnesium was not found in a carbonate form in surface soils except in minute quantities in soil moisture immediately after treatment with carbonate. Pure alkaline silica brought into moist contact with carbonates of calcium and magnesium and dolomite caused carbon dioxide to be set free. The decomposition of magnesium carbonate was also brought about by contact with titanium oxide.

A study of the solubility effect of ammonium sulphate on soil was carried on at the Massachusetts station and interesting results were obtained. An analysis of the drainage water from soils thus treated showed an exhaustion of lime as a base but no accumulation of free sulphuric acid. Apparently the chemical reaction which took place consisted chiefly in the formation of soluble sulphates of calcium, aluminum, and iron. Soil studies at the New Hampshire station indicated that the soils of the State are rich in potassium, which occurs both in clay and undecomposed mineral form. Calcium carbonate exercised practically no effect on the solubility of soil potassium. The effect of chlorid, nitrate, and carbonate of sodium, and of acid phosphate was to increase greatly the solubility of soil potassium. When potassium phosphate was added to the soil no new soluble salts appeared in solution. The conclusion was drawn that the use of potassium fertilizers on these soils is unprofitable.

The effect of certain salts of heavy metals on the ammonification and nitrification of soils was investigated at the California station. During these experiments it was found that copper, arsenic, iron, and

lead are toxic to the ammonifying flora of the soil in all concentrations from 50 to 2,500 parts per million, and are not stimulating to the ammonifying flora at any degree of concentration. The same salts, however, proved highly stimulating to the nitrifying flora of the soil. At the Kentucky station the presence of relatively large amounts of manganese in the seed coat of various plants was demonstrated, indicating the possible function of manganese as an oxygen carrier in the germination of the seed. When added in minute quantities to the soil, manganese carbonate exercised a marked beneficial effect on the growth of alfalfa. In experiments with tobacco it was shown that this plant sometimes absorbed barium to an extent twice the maximum reported in loco weed.

In a continuation of the study of the effect of arsenical sprays upon orchard soils at the Utah station much attention was given to the solubility of lead arsenate. It appeared that some virgin soils contained arsenic in appreciable quantities as a result of the decay of the native rocks. No constant relation was observed in orchard soils between the total quantity of arsenic and the water-soluble arsenic. One soil which contained a hundred parts per million of total arsenic contained less water-soluble arsenic than another soil which had only five parts per million of total arsenic. At the Hawaii station it was demonstrated that arsenite of soda extensively used as a chemical spray for killing weeds was almost instantly fixed by the soil. In none of the soils upon which experiments were made was it possible to recover arsenic from a depth lower than 1 inch after large quantities of a solution of arsenite of soda had been poured upon the soils.

The nature of soil acidity was studied at the Michigan station. Indications were found that the reaction of so-called acid soils of the sandy loam type is one of selective adsorption by the soil of basic constituents of the neutral salt solution. It appeared that the acidity of soils of this type arose from the formation of double salts through the interaction of weak acids in the soil solution. At the Iowa station it was shown that on southern Iowa loess soils  $3\frac{1}{2}$  to 5 tons per acre of lime were indicated as the natural requirement of these soils, which are underlaid by acid subsurface soils. After the acidity of the soil was once neutralized, the use of 1 to 2 tons of lime every four or five years proved to be sufficient.

An unproductive soil of the Kankakee marsh region was investigated by the Indiana station. It appeared that the acidity of the water extract from these soils was directly proportional to the amount of alumina present in the solution, and that it indicated not actual free acid, but the amount of alkali required to precipitate the aluminum salts. In water cultures it was demonstrated that very dilute solutions of aluminum nitrate were toxic to corn in the pres-

ence of mineral nutrients. Cold-water extracts of the unproductive soils showed about the same toxicity as solutions of aluminum nitrate containing the same amounts of aluminum. The nitrate of these soils was found to be in part combined with aluminum, and that compound was apparently the cause of the unproductiveness.

The effect of crops upon nitrification in the soils was investigated at the New York Cornell station. Corn appeared to stimulate the formation of nitrate in the early stages but to retard it later. More nitrification took place in bare plats than in those on which grass was grown. All plants with which experiments were made appeared to depress nitrification as the plants approached maturity, the amount of nitrates being then reduced below a point which would be accounted for by the total nitrogen removed by the crop. At the Oregon station the number of bacteria in soils low in organic matter was found to be small as compared with the number in peat and muck soils. Lime showed no effect upon the number of bacteria, except in distinctly acid soils. There appeared to be a direct correlation between the amounts of ammonia formed and the number of bacteria. Great variations in ammonifying powers of different soils were noted.

Similarly, at the Colorado station differences in nitrification were observed. The Colorado soils appeared to be superior in nitrifying power to soils from 22 localities outside of the State. The nitrifying flora of Colorado soils appeared to be different from that found in the majority of soils from outside the State, or at least to show a different proportion among the constituent organisms. The presence of excessive nitrates did not interfere seriously with nitrification so long as the content of chlorin was low.

An examination of so-called niter spots by the Utah station indicated that the soils which have a high niter content also show a high percentage of other alkali salts, such as chlorids and sulphates of sodium, calcium, and magnesium. Much of the country rock contributing to the formation of these soils was shown to be heavily impregnated with nitrate accumulations. The brown spots which appear where excessive accumulations of nitrates occur on the surface were not confined to cultivated soils.

The utilization of nitrogen by cereals and other field crops was investigated at the New Jersey station. On all except very sandy soils nitrate of soda showed a higher availability than dried blood. The average percentage of nitrogen in the dry matter of the plants was higher after fertilization with nitrate of soda than after dried blood. The influence of manure applied in connection with leguminous crops to be plowed under appeared to be beneficial, to the extent that bacteria introduced with the manure helped to bring about a more rapid decomposition of the leguminous material. At the

Iowa station it was shown that applications of manure up to 16 tons per acre increased the number of bacteria in the soil, and also the ammonifying power of the soil. The greatest increase in the number of bacteria and in ammonifying power was shown in comparing the check soil and that receiving 8 tons of manure per acre, and in comparing an 8-ton and a 12-ton application. The use of 20 tons of manure caused a depression in the number of bacteria, the ammonifying power, and the nitrifying power. The yield of corn was affected in the same manner, being increased with applications of manure up to the extent of 16 tons per acre.

Similarly, at the Georgia station the number of bacteria in the soil was found to be considerably increased by the use of barnyard manure. At the Idaho station it was shown that the nitrifying organisms were not washed out of the soils to an appreciable extent by irrigation.

A study of six species of nitrogen-fixing bacteria at the Kentucky station indicated that these species may produce nodules on only one plant, or on several kinds of plants, in some cases not all of one genus. All of the species of clover were found to be affected by a single species of nitrogen-fixing organism so that a culture made from one species of clover would produce nodules on the roots of any other member of the genus. The nodule organism on alfalfa and sweet clover was found to be identical and to affect also other species of *Medicago*. A study of the nitrogen-fixing bacteria at the Cornell station indicated that the virulence of the organism can not be altered by poor nutrition but that the duration of its life may be affected. It was found that sulphates and ammonium salts tended to inhibit the production of nitrogen nodules, while chlorids and phosphates stimulated their development.

#### VETERINARY INVESTIGATIONS.

Among the large number of veterinary investigations at the stations a few may be selected as being perhaps of striking interest. At the California station an opportunity was had to determine the reliability of the intradermal test for tuberculosis in cattle by a study of 4,926 intradermal tests. The accuracy and value of the method was shown to be very high. The intradermal method proved also to be especially well adapted in testing hogs for tuberculosis.

At the North Dakota station tuberculosis in fowls was shown to involve the liver most frequently. Intradermal tests for tuberculosis in fowls gave satisfactory results. The comb and wattles appeared to be the best locations for making the test. Reactions after injection in the wattles were most constant and regular, becoming most pronounced about 48 hours after injection.

A study was made of the cause of cattle bloat while feeding upon red or white clover and alfalfa at the Kentucky station. It appeared that the bloat was due to the fermentation of sugar which was found to constitute  $2\frac{1}{4}$  per cent by weight of the first blossoms of clover and alfalfa.

As a result of further studies on bovine red-water at the Washington station it appeared that this is a specific disease of common occurrence in the western part of the State. The cause of the disease has not yet been determined. The blood of infected animals was shown not to be virulent but the disease was transmitted by inoculation with bladder lesions.

At the Arkansas station the significance of bacterial infection in hog cholera was investigated with particular reference to *Bacillus suipestifer* and *B. suisepcticus*. It appeared that the bacilli of the hog-cholera type occurred rather infrequently in natural outbreaks of the disease as compared with hogs artificially infected. The prevalent type of the disease in the State was not accompanied by mixed infection. It was shown that hogs which are protected against true hog-cholera virus by vaccination are also protected against infection with *B. suipestifer*. The high agglutinating power toward *B. suipestifer* in a sample of antiserum was not considered as an absolute index of its potency against true hog-cholera virus, but as an indication that it was produced by a virulent strain of hog-cholera virus.

#### INSPECTION OF THE STATIONS.

In accordance with the usual practice of the office, a personal inspection was made during the year of the work and expenditures of each of the experiment stations receiving Federal funds. This inspection served as the means of securing a large amount of first-hand information in regard to the progress of the stations and their relations to the colleges with which they are connected and to the agriculture of the States, and the opportunity was embraced for conferences with the station officers in regard to station organization and administration. This inspection was participated in by four members of the office force—the assistant director (E. W. Allen), W. H. Beal, Walter H. Evans, and J. I. Schulte.

The following reports upon the several stations are based on the results of this inspection, together with the annual financial statements of the stations, rendered on schedules prescribed by the Secretary of Agriculture, and the printed and other reports received from station officers.

**ALABAMA.**

**Agricultural Experiment Station of the Alabama Polytechnic Institute,  
Auburn.**

J. F. DUGGAR, M. S., *Director.*

The work of the Alabama station for the year was in most part along the same lines as in previous years. Several changes on the staff occurred. J. M. Jones resigned as head of the department of animal industry and his position was filled by the appointment of G. S. Templeton. Ernest Walker, of the Arkansas station, was appointed head of the horticultural department. A. B. Massey, formerly connected with Clemson College, was appointed as assistant botanist. While considerable energy and time were spent by members of the station staff in demonstration and extension work, most of the scientific projects were kept in operation with sufficient activity to yield distinct progress.

*Adams fund projects.*—Particularly satisfactory advance was made under the Adams fund in agronomy, entomology, botany, and plant pathology. This was the eighth year of work on the cotton-breeding project. A large mass of data had been accumulated and is being classified, so as to show the correlations and inheritance of certain characters, such as size and seed and bolls. Noticeable progress was also made in corn breeding, which is also concerned primarily with correlation of characters, and in oat breeding, which is devoted largely to an attempt at breeding off the beard and securing earliness. Some progress was also made in the study of potato storage. A new cellar was built, several varieties of potatoes held in storage, and careful readings taken of temperature and humidity.

In the study of the rice weevil as an enemy of corn it was found that the pendant ear, well covered with husks, is the most resistant type; that husking in the field is of decided advantage; that a few rows of early corn may be planted as a trap crop and fed to stock; and that the pest in stored corn can be destroyed by fumigants. A study of the results of experiments in storing corn at Prattville, Ala., showed an average infestation of 10 weevils per ear for husked corn and 43 weevils per ear in unhusked corn. In cases where infestation was serious fumigation with carbon bisulphid is recommended at the rate of 5 to 8 pounds per thousand cubic feet in tight bins and at the rate of 20 to 25 pounds per thousand cubic feet of space for ordinary bins which allow more leakage of the gas.

The fumigation project of the station has been confined chiefly to carbon bisulphid and formalin. A study is being made of the efficiency of fumigation and the effect upon germination of seeds. In the project on arsenicals several brands of arsenate of lead were

tested with an idea of standardizing them, and arrangements were made for strict chemical control of the materials used through the cooperation of the chemist.

Some difficulty is experienced in growing cotton under artificial conditions for the purpose of studying the fertilizer requirements of this plant. The work on this subject has thus far shown no distinct correlation between potash fertilizers and the growth of cotton plants for the first four or five weeks.

In continuing the study of the effect of feeds on the quality of pork, the original point of view was somewhat changed, and determinations were made of the chemical changes which occurred in the course of time in the samples of lard produced from different feeds. By way of throwing a side light on the study of the poisonous effect of cottonseed meal upon animals, moldy corn was fed to mules and was found to produce in some instances a chronic inflammatory condition in the stomach.

The definite antagonism between certain salts observed in water cultures with corn and cotton was found to disappear in quartz sand cultures. Important data are being collected covering the antagonism of sodium salts toward seven other salts. The organism which causes the Sclerotium rot of the peanut has been isolated.

*Work with Hatch and other funds.*—With the support of Hatch and State "local experiment" funds, several lines of experimental work were carried on. It appears that in order to secure larger yields of oats in Alabama sowing in early fall is important. Some variety of the red rust-proof group of oats should be used, and all seed treated with formalin. The station experiments indicated that nitrate of soda was the most effective commercial source of nitrogen for oats, and that acid phosphate was more effective and economical than ground rock phosphate.

In 65 per cent of the station tests of fertilizers for cotton, acid phosphate was found to be needed for the best growth of cotton. Complete fertilizers proved more profitable than fertilizers applied singly or in pairs. It appeared that 200 pounds of cottonseed meal was equal to 100 pounds of nitrate of soda for cotton. The greatest profit from the application of fertilizers was obtained by using a combination of acid phosphate, kainit, and nitrate of soda. In grading cotton for oil content it was found that a high percentage of protein is characteristic of heavy seed and a high percentage of oil characteristic of light seed. Cotton seed with a high oil content was found to be low in protein.

A great variety of cooperative experiments have been made possible by the "local experiment" fund. In this work cooperation has been carried on with farmers in 300 localities throughout the State

on varieties of cotton and corn, effect of Williamson method of corn growing, methods of rotation, and fertilizers for various forage crops. In cooperation with this department an experiment was carried on to test the value of silage in connection with cottonseed meal for fattening steers.

Along horticultural lines work is being carried on with root rot of grape, fertilizers for pecans with reference to their effect on the fullness of kernel, grafting of pecans, deep mulch for asparagus, keeping properties of sweet potatoes, and varietal resistance of lettuce toward root rot.

A study of the biology of the cattle tick showed that the period between full engorgement with blood and the beginning of egg laying ranged from 2 to 29 days, the egg-laying period from 7 to 152 days, the incubation period for the eggs 18 to 180 days, and the entire period of nonparasitic life of the ticks from 70 to 297 days.

A survey was made of the progress of the boll weevil in cotton and of the prospects for the cotton industry as influenced by this pest. While extremes of cold and wet weather in winter have, in some localities, exterminated the weevils, these climatic agencies can not be depended upon in Alabama. Some help may be expected from early frosts, which may occur toward the end of October. In Mobile and Baldwin Counties, where cotton has never been a really important crop, the yield has dropped to one-third of the average during the past five years as a result of infestation. A survey of the situation indicated that no cotton district of Alabama can hope to escape infestation by the boll weevil.

A study was made of the cost of raising beef calves to an age of  $9\frac{1}{2}$  months under average farm conditions, and also of the profit from finishing these calves for market during the winter months and selling them at the age of 12 months. The calves used in this experiment were grade Aberdeen Angus, born during the spring months and allowed to run on pasture with the cows until late fall, after which they were weaned and fattened. It was found to cost on an average \$14.36 to raise each calf to an age of  $9\frac{1}{2}$  months, the average cost per hundredweight being \$3.12. After the calves had been finished for the market they were sold at \$5.87 $\frac{1}{2}$  per hundredweight, with an average profit of \$6.81 per calf.

The publications received from this station during the year were as follows: Bulletins 171, The Biology or Life History of the Cattle Tick as Determined at Auburn, Alabama; 173, Oats—Experiments on Culture, Varieties, and Fertilization; 174, Local Fertilizer Experiments with Cotton in South Alabama in 1913; 175, Local Fertilizer Experiments with Cotton in Northern Alabama in 1913; and 176, Reducing Insect Injury to Stored Corn.

The income of the station for the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----                         | \$15,000.00 |
| United States appropriation, Adams Act-----                         | 15,000.00   |
| State appropriations, including balance from previous<br>year ----- | 30,148.47   |
| Farm products-----  | 995.48      |
| Miscellaneous-----  | 3,525.71    |
| Total-----  | 64,669.66   |

The station has been enabled to meet many of the demands for the solution of practical problems among farmers, and to make its influence felt for good throughout the State by means of the "local experiment" fund, which, as in previous years, was used in various well-organized lines of practical inquiry.

*Tuskegee Agricultural Experiment Station, Tuskegee Institute.*

G. W. CARVER, M. Agr., Director.

The Tuskegee station continued in a systematic way the lines of work which were already in progress, and during the year added lines of study on the varieties of tomatoes and sweet potatoes with a view to determining varieties which are best for canning purposes. Canning operations are being prosecuted on a large scale and information regarding suitable varieties of tomatoes and sweet potatoes for canning was much needed.

A study was made on the soils of Macon County, Ala., about 10 types of soil were described, and their geographical distribution indicated. Upon this basis a survey was made, during which much information was collected on the methods of treatment, fertilizers, and crops best adapted to each type of soil. The members of the station staff take part in extension work of various kinds among colored farmers, in order to bring about improved cultural methods and to secure the wider use of new and improved varieties of farm crops.

The only publication received from this station during the year was Bulletin 25, *A Study of the Soils of Macon County, Alabama, and Their Adaptability to Certain Crops.*

The station is maintained by an annual State appropriation of \$1,500.

#### ALASKA.

*Alaska Agricultural Experiment Stations, Sitka, Kodiak, Rampart, and Fairbanks.*

C. C. GEORGESON, M. S., *Special Agent in Charge, Sitka.*

The Alaska stations continued the work of developing the agricultural possibilities of Alaska along the same lines as heretofore.

There were no changes in the staff or the policy of the stations during the year. The winter of 1913-14, while not extremely cold, was marked by light snowfall. This furnished a severe test of the hardiness of cereals. At Fairbanks and Rampart the winter wheat, alfalfa, and clovers were completely killed, except the Kharkov variety of wheat, while rye survived the trying conditions well. This is taken as indicating the commanding position of rye as a winter cereal for Alaska. The repeated freezing and thawing which occurred during the winter at the Sitka station destroyed many seedling plants, but had little effect on well-established perennials.

At the Kodiak station the alternation of freezing and thawing, together with melting snow, rains, and winds, carried much of the volcanic ash down the slopes upon the lowlands, with the result that the native grasses became rapidly reestablished on the slopes and hillsides, while on the lowlands the beach grass (*Elymus mollis*), which has been used for silage heretofore, was to a large extent buried and destroyed. Recourse was had, therefore, to oats and tame grasses for silage purposes. An ensilage cutter and gasolene engine were purchased for preparing material for the silo. The cattle herd, which had been temporarily kept at Chehalis, Wash., was brought back to the Kodiak station in July. Some of the animals of the herd, particularly those of the beef type, were sold in order to develop from the remainder of the herd a dual-purpose animal of better milking quality. The herd continues to give excellent results. The flock of sheep at the Kodiak station has shown its adaptability to that climate, although a few of the animals died suddenly with symptoms of poisoning.

It has been found that grasses and grains planted on the volcanic ash must be supplied with nitrogen to make satisfactory growth. Wherever the layer of ash is not too thick it has been found that plowing to a depth of 18 inches gives excellent results, since some soil is thereby mixed with the ashes, furnishing sufficient plant food and improving the tilth of the soil as a whole. For this deep plowing it was found necessary to have a special plow constructed.

The dairy barn at Kodiak was completed by laying a cement floor and constructing modern dairy stalls. Henceforth it is proposed to maintain two distinct herds at the Kodiak station, one of select dairy cows at the town of Kodiak, and a general breeding herd at Kalsin Bay.

An active demand has arisen for seed potatoes grown at the Fairbanks station, and selected seed potatoes were sold readily at 10 cents per pound. The work of the station was furthered by the purchase of a team of horses, which were secured in the Puget Sound country. Experiments have been outlined to form a basis for a rational system

of rotation. It has been found that consecutive grain crops can not be grown profitably, the available plant food being too rapidly exhausted. In order to maintain the fertility of the soil, a system of rotation with summer fallowing and green manuring will be adopted. The live-stock equipment at the Fairbanks station has been increased by the purchase of six pure-bred Duroc-Jersey pigs.

Some Petrowski turnip seed was harvested during the spring. Experiments seemed to indicate that a good quality of turnip seed can be grown at Fairbanks, as well as at Rampart. If this should prove to be the case, it may be possible to develop an industry in Alaska turnip seed. The fields of the Fairbanks station are used to test out on a larger scale the grains and other sorts of crops which come from the breeding experiments at the Rampart station. Any important results which arise from such tests can conveniently be brought to the attention of farmers in the neighborhood of the Fairbanks station. It is proposed to clear an additional 30 acres of land at Fairbanks for experimental purposes.

At the Rampart station grain breeding will be emphasized more than in the past, and work with hardy alfalfas will be still more extended, partly for the purpose of determining whether a suitable alfalfa seed can be produced in Alaska. The sweet clover and alfalfas seeded during the previous year, with the exception of one from the Gobi Desert, were winterkilled. The old-established plats of Grimm alfalfa and *Medicago falcata*, however, did not suffer greatly. A galvanized tank with a capacity of 5,000 gallons is being installed as a water reservoir for use of stock during the winter. By sinking this tank into the ground under the barn it is hoped to prevent freezing of the water during the severe weather.

At the Sitka station the horticultural work begun in previous years has been continued and extended. In addition to breeding strawberries, crosses have been made with currants and gooseberries, as well as attempts at hybridizing species of *Rubus* and wild crab-apple with cultivated varieties. A number of crosses between roses are also reported. A determined effort is being made to produce by breeding or secure by importation varieties of all kinds of fruits better adapted, if possible, to Alaska than those which are now available.

The several hundred seedling strawberries which have been produced are being studied for the purpose of selecting those which are especially meritorious and eliminating the rest. Some of the hybrids have shown a decided tendency to early maturing. Rather extensive variety tests are in progress with vegetables, particularly the Cruciferae and potatoes.

The only publication of the station for the year was the annual report.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation                 | \$35,000.00 |
| Sales, including balance from previous year | 12,740.79   |
| Total                                       | 47,740.79   |

The station has had encouraging success in interesting citizens of the Territory in the possibilities of agriculture and is generally looked to as a source of information on all matters concerned with the special conditions of farming in Alaska.

#### ARIZONA.

**Agricultural Experiment Station of the University of Arizona, Tucson.**

R. H. FORBES, M. S., *Director.*

The more notable features of the work of the Arizona station for the year were studies of dry farming in the northern part of the State, breeding sweet corn and wheat, and the study of ground waters. The horticultural work of the station received an impetus through the appointment of W. H. Lawrence as horticulturist. J. C. T. Uphof was appointed assistant plant breeder. Plans were completed for a new agricultural building, which is expected to be both handsome and useful. The area of experiment farms under the supervision of the main station was considerably increased, especially by the purchase of a farm in Salt River Valley, the location of a new substation near Mesa, and by increasing the area of the Yuma station.

*Adams fund projects.*—On the Adams fund projects perhaps the most active research was done in breeding work with alfalfa, beans, wheat, and sweet corn. Projects on breeding of wheat and sweet corn were added to the work of the station during the year. Special apparatus and methods are being devised for the purpose of studying the water requirements of different strains of alfalfa, and rather striking differences have been observed. The various strains of alfalfa are being tested at Phoenix and Yuma, as well as at Tucson. In the sweet-corn work the cause of frequent failure of pollination is being carefully studied. With wheat the principal object of the investigation is to determine the mode of transmission of hardness in the grain. The study of the transmission of physiological characters in tepary beans was continued.

Progress was also made on the study of underflow or ground water, the effect of temperature on ripening of dates, on the factors which determine hardiness in cactus, and on the toxic effect of copper compounds on wheat. It was found that date palms show most rapid growth at the period of highest minimum temperatures—that is,

during a period of warm nights, rather than at the period of highest maximum temperatures. Consequently, the greater part of the total annual growth of the date palm occurs in the second half of the year. The rate of ripening of the fruit was found to be affected by the same factors and in the same way.

The study of underflow or ground water consisted chiefly of observations on the efficiency of pumping machinery and suitable methods of sinking wells for raising underground water. A caisson well, devised by the station, proved very effective. Attention was also given, as an incidental part of this project, to the care and operation of gasoline engines used for pumping. Since the effective and continuous use of gasoline engines depends upon a thorough understanding of their operation, a study was made by the station of the troubles which usually occur in operating these engines. In order to make their use for pumping purposes a simple and practical matter, the station devised a tabulated chart or key for the purpose of enabling the operator of gasoline engines to locate the cause of the trouble quickly and accurately.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds the station carried on a considerable number of comparative tests in certain parts of the State, particularly with varieties and methods of culture of cereals, sugar beets, sugar cane, forage sorghums, alfalfa, and tepary beans. Sheep were used successfully in keeping the banks of irrigation canals free from weeds and grass. Progress was also made in devising suitable means of control for woolly aphid, the bean lady-beetle, harvester ant, and green June beetle. Systematic efforts are being continued to find a more hardy cactus for growth on the range. The chemist continued his study of methods of alkali determination and of the changes which occur in the salts of Salton Sea water. In the horticultural department information of importance was collected toward an understanding of varietal adaptations of grapes in Arizona and regarding factors which control the pollination of dates.

In the continued study of dry farming it was found that in some localities of the State summer fallowing by the ordinary methods is not a successful method for permanently accumulating water in the soil, even with a two-year fallow. Supplemental irrigation wherever possible proved to be much cheaper than summer fallow. Thorough tillage of summer-grown crops proved profitable in every instance. In general better results were obtained in dry farming on light than on heavy types of soil. Wherever supplemental irrigation is possible the station recommends that cereals and other dry-farm crops be started by means of irrigation in advance of the ordinary season of rainfall, since otherwise the yield may not be satisfactory. In the dry-land experiments of the station milo maize proved to be the

best grain crop, while tepary beans were considered as occupying the second place from the standpoint of financial returns.

A comprehensive study of alfalfa in Arizona indicated that this crop may be grown on most types of soils found within the State. Alfalfa is little affected by altitudes, since it was found to thrive well at Yuma at an elevation of 100 feet and at Prescott at an elevation of 6,000 feet. Alfalfa did not prove successful, however, where the water table was less than 2 feet below the surface. The total cost of producing and harvesting an acre of well-established alfalfa was found to be \$17.10, on an average, and the total returns \$48, leaving a profit of \$30.90 per acre for loose hay. Where the hay was baled the net returns per acre were \$33.90. Some attention was given to the chalcis fly (*Brucophagus funebris*) which is perhaps the worst enemy of alfalfa seed in the State. At Phoenix, in badly infested districts, this pest destroyed 74 per cent of the seed and 80 per cent of the seed at Tucson. The loss appeared to increase as the season advanced until the destruction was nearly complete in October.

The only publication received from this station during the year was Bulletin 70, Dry Farming in the Arid Southwest.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----   | \$15,000.00 |
| United States appropriation, Adams Act-----   | 15,000.00   |
| State appropriation, including balance from previous<br>year -----                                    | 62,943.64   |
| Southern Pacific and El Paso & Southwestern Rail-<br>roads, including balance from previous year----- | 2,779.83    |
| Farm products, including balance from previous year-----  | 5,143.64    |
| Total-----  | 100,867.11  |

The year was one of great activity at the station. A State farm improvement association was organized for the purpose of promoting cooperation between the farmers and the station. This is expected to bring about a more systematic application of the scientific results of the station in the improvement of cultural practices on the farm.

#### ARKANSAS.

**Arkansas Agricultural Experiment Station, Fayetteville.**

MARTIN NELSON, M. S., *Director.*

A slight reorganization of the work of the station relieved the director of investigational work, leaving his time free more largely for administration. The staff was strengthened by the addition of assistants in agronomy, animal husbandry, horticulture, and plant pathology. W. H. Wicks, of Idaho, was appointed horticulturist in

place of Ernest Walker, resigned. The administrative methods were improved and the project system extended to permit better control of the work of the station as a whole. Arrangements were made for the establishment of a plant for manufacturing hog-cholera serum in Little Rock.

*Adams fund projects.*—The study on the new and unknown apple-tree disease was continued. The growth and microscopic appearance of the disease were studied and described, but the cause of the disease has not yet been discovered.

As a result of the investigation of pear and apple blight it appeared that these diseases are due to different strains of the same organism. The possibility of developing resistant varieties and of controlling the spread of the disease by insecticidal methods which will destroy aphides, bark beetles, etc., was considered. Great differences were observed in the resisting power of different varieties of apple to blight. Shannon Pippin is especially subject to blossom blight and Yellow Transparent appeared to be particularly susceptible to twig blight. Experiments in artificial inoculation with *Bacillus amylovorus* were largely without result. It was concluded, therefore, that there is a considerable degree of resistance of all the varieties of apples to this organism. In all cases the trees which received the best care were most resistant. Chemical analyses of twigs and fruit spurs taken from different orchards indicated a fairly definite relation between starch content and susceptibility to blight. The varieties which contained the higher percentages of starch were the more susceptible.

The rôle of bacterial infection in hog cholera was thoroughly investigated, particularly with reference to *Bacillus suipestifer* and *B. suisepcticus*. It was considered of importance in the preparation of an antiserum to know in what degree, if any, the results of vaccination may be influenced by the presence or absence in the serum of antibodies to bacterial infection. In experiments with hogs inoculated with the filterable virus and *B. suipestifer* the effect of the bacillus was seen in the shortening of the incubation period, a greater severity of the symptoms, and the more rapid course of the disease. Little evidence was obtained of the transference of bacillary infection to exposed animals.

Infection with *B. suipestifer* is believed not to be dependent to any great extent on transference from animal to animal. The theory that the bacilli, so generally to be obtained from the organs of hogs suffering from hog cholera, really belong to a considerable variety of organisms was not supported by these investigations. All strains appeared to be identical in cultural and biological characters. It was shown that high agglutinating power in a sample of antiserum was

in general an indication that it was produced by the use of a virulent strain of cholera virus. A large amount of work was also done along the line of complement fixation and agglutination in the diagnosis of hog cholera. The possibility of producing immunization by serum-free blood cells modified by heat was also tried with promising results.

Only slight progress was made in the study of the elements of plant fertility removed by peaches and apples. It was proposed to confine this experiment hereafter to apples. In a study of cotton breeding attention was devoted to inheritance of fruit characters in hybrids, variation of commercial varieties, and the effect of selection of seed of long-staple cotton grown continuously on high upland soil.

Encouraging progress was made in the resistance of apple stocks of different varieties to the woolly aphis and to the study of the life history and host relationships of this insect. Experiments were begun on the effect of transferring different forms of the insect from one host plant to another for the purpose of determining its life history on different hosts, particularly elm and apple. A further study of the roundheaded apple-tree borer indicated that the control of this insect by asphaltum treatment of trees was probably impracticable, on account of the injury done to the trees by the asphaltum.

*Work with Hatch and other funds.*—The experimental work carried on under the support of Hatch and other funds was mainly in the departments of agronomy, horticulture, and entomology. The general study of the adaptability of oats to Arkansas indicated that the winter varieties produced taller straw and larger yields of heavier grain than the spring variety, but that spring varieties mature earlier and show less tendency to lodge than do the winter crops. Northern oats gave unsatisfactory results in comparison with the southern strains. As an average of five years' experiments it is recommended that spring oats be seeded at the rate of 10 to 12 pecks per acre. A similar study of the conditions necessary for improving corn culture in Arkansas led to the recommendation that seed corn should be selected while the corn is standing in the field, that the seed should be stored in racks or on wires providing the most perfect ventilation, and that choice should always be made of a variety which has shown its superiority in the particular region in question in comparison with other varieties. Similar practical experiments were carried on with wheat and various forage crops.

The horticultural experiments included variety tests of blackberries, asparagus, cherries, peaches, and pears, a monographic study of grapes, fertilizer experiments with potatoes, the study of the effect of stock on scion in the case of apples, and a general fruit survey of the State to obtain practical information on the varieties of different fruits most promising in Arkansas.

Observations were made in various localities in the State on the period of emergence and egg-laying habits of the peach borer. White lead proved an unsatisfactory means of preventing the attacks of this pest. In cooperation with the plant pathologist, numerous tests were made of combined sprays for the San José scale and apple scab. The new insectary, completed during the year, greatly facilitated the entomological work. In a series of spraying experiments it was found that apple trees could be safely sprayed with strong lime-sulphur mixture at the time suitable for the first spraying for apple scab. Injury to peach trees from commercial lime-sulphur in commercial orchards was found to be due largely to mistakes in preparing the mixture. Extensive experiments with rice by-products in rations for swine gave results quite favorable to the use of rice bran, but showed that rice polish was less valuable for this purpose.

The following publications were received from this station during the year: Bulletins 112, An Unknown Apple Tree Disease; 113, Twig Blight and Blossom Blight of the Apple; 114, Spraying Investigations for 1912; 115, Corn Improvement; 116, Varieties of Fruit for Arkansas; Circulars 17, The New Arkansas Law with Reference to the Inspection of Nurseries and the Transportation of Nursery Stock; 18, The New Local Option Orchard and Small Fruit Inspection Law; 19, Fumigating Nursery Stock; 20, Pruning Young Fruit Trees; and 24, Instructions to Members of the Boys' Corn Club.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----               | \$14,988.00 |
| United States appropriation, Adams Act-----               | 14,900.00   |
| Balance from United States appropriation, Hatch fund----- | 12.00       |
| Balance from United States appropriation, Adams fund----- | 100.00      |
| State appropriation -----                                 | 49,000.00   |
| Individuals-----  | 1,791.88    |
| Farm products-----  | 2,529.07    |
| Miscellaneous -----                                       | 6,513.48    |
| Total -----   | 89,834.43   |

The standing of the station is gradually becoming stronger. Its recent work has contributed greatly toward creating a better sentiment among the people of the State.

#### CALIFORNIA.

Agricultural Experiment Station of the University of California, Berkeley.

T. F. HUNT, D. Agr., D. Sc., Director.

With a greatly increased appropriation, the California station was enabled to extend its operations in all lines, both in scientific and practical work. The force of men engaged in prosecuting these in-

vestigations was increased by the appointment of nearly 50 additional workers during the year. An insectary was erected, offering facilities for the study of parasites and various other entomological problems. Two new and elaborate greenhouses were built for use in agronomy, citriculture, genetics, and plant pathology. A hog-cholera serum plant was constructed, providing better accommodations for the study of hog cholera. In the Imperial Valley 10 acres was added to the experimental farm, thus increasing the area of this farm to 40 acres. One of the specially notable features of the station's activities during the year was the large amount of work actually begun or accomplished at the Citrus substation at Riverside.

*Adams fund projects.*—Most of the Adams fund investigations carried on by the station have assumed the form of group projects and have been subdivided into a number of subprojects. On all of these satisfactory progress was made. In the study of tuberculosis in cattle nearly 5,000 intradermal tests were made, showing the great value of this method because of its reliability. Many cases of tuberculosis were detected, and in the early stages ordinary subcutaneous tuberculin tests gave no results. Some evidence was obtained, however, that even the intradermal test is unreliable when applied only a few days after the subcutaneous injection. The intradermal method proved to be especially well adapted to testing hogs for tuberculosis. An extensive study is being made throughout the State, which throws light on the conditions under which tuberculosis in cattle spreads.

In the field of so-called physiological plant diseases particular attention was given to internal brown streak of the potato, little leaf of cherry, die-back of the olive, and curly top of sugar beet. In the case of the potato disease a study is being made to determine the importance of such factors as time of planting, amount of soil moisture, fertilizers, and time of harvesting. Some evidence was obtained that curly leaf of sugar beet may possibly be carried from plant to plant by the stings of *Eutettix tenella*.

The study of bacteria in arid soils has naturally fallen into various subdivisions, and the work is being prosecuted along more specific and limited lines. The effect of the salts of heavy metals on ammonification and nitrification in soils has been studied, and the results are of wide interest. It appears that copper, zinc, iron, and lead are toxic to the ammonifying flora of soils in all concentrations from 50 to 2,500 parts per million, and are not stimulating to the ammonifying bacteria in any concentration. The same salts, however, prove to be highly stimulating to the nitrifying flora of the soil. In a study of ammonification in soils by means of pure cultures, it was found that the nature of the soil and of the nitrogenous material furnished for ammonification greatly modified the ammon-

ifying power of the microorganisms. On the whole *Bacillus tumescens* appeared to be the most efficient ammonifier for all kinds of nitrogenous substances, but with peptone *Sarcina lutea* was most efficient, transforming 42 per cent of the nitrogen into ammonia within 12 days.

In the study of the toxicity of insecticides, an attempt is being made to investigate all the factors which may have any influence upon the effect of insecticides of whatever nature. These factors may be physical and climatic or chemical and biological. During the year a study was made of the action of constant strengths of cyanid on insect eggs, thousands of tests being made to determine the important features of this matter. A study is also being made of the strength of tent material in order to determine the best quality of tent cloth from the standpoint of its efficiency in preventing the leakage of hydrocyanic-acid gas.

Five series of experiments are being conducted on the subject of tobacco hybrids. These studies are yielding results of considerable interest from the standpoint of plant breeding. The points which are receiving chief attention at present are the behavior of sterile and partially sterile hybrids, the fixation of hybrids, the behavior of hybrids between varieties of European tobacco, and hybrids between wild species or native Indian tobaccos in California.

*Work with Hatch and other funds.*—Under support from the Hatch, State, and other funds a great variety of work is being prosecuted in all parts of the State. This work has been organized upon a project basis and includes in all nearly 200 projects.

Some of the most interesting work is being done at the Citrus Experiment Station, which is supported entirely by State funds. Several lines of work have already begun to yield results at this substation. A study of the fertilizer requirements of citrus fruits indicates the importance of nitrogen fertilization and the desirability of using nitrogen from organic sources rather than from nitrate of soda. Numerous legumes have been tried as cover crops or for green manuring of citrus. The purple vetch and sweet clover proved to be especially promising for this purpose. Elaborate studies are in progress on varieties of citrus fruits, efficiency of various devices for heating orchards, the crown-gall organism, black pit of lemons, lemon decay and gum diseases of citrus fruits, and a protracted investigation of nematode injuries to citrus.

In the study of citrus fruits at Davis it was found that in all naturally fertile varieties of orange trees self-pollination is the rule and cross-pollination is unnecessary. Spraying experiments for walnut blight have been conducted on more than 50 acres of large walnut trees, in which it appeared that these trees could be sprayed for about 50 cents per tree, and that the results of spraying with lime-sulphur

were decidedly satisfactory. In the field of viticulture numerous experiments were carried on, indicating that pruning before the leaves fall somewhat delayed the starting of buds and that whitewashing had a similar effect. Pruning after the terminal buds had started seemed to increase the crop irrespective of the frost injury. Late pruning delayed the ripening of the crops, while pruning in May decreased their quality. Numerous tests showed that cuttings or roots may be safely disinfected by immersion for five minutes in water at 55° C.

The possibility of utilizing waste oranges was studied. It appears that the main difficulty in producing a satisfactory orange juice is the mechanical one of rapidly and economically separating the juice from the solid parts of the fruit. The clear juice was found to keep perfectly after bottling if pasteurized at 180° F. A satisfactory orange wine was made from this juice by fermentation with pure yeast and filtration. Vinegar made from the wine was not equal to cider vinegar and showed a tendency to fall below the legal strength of acetic acid.

A further study was devoted to a variety of the California black walnut which has oaklike leaves. It was found that this new variety may appear among the normal progeny of trees which yield mostly the ordinary form of walnut. Attention is also being given to the hybridization of peaches, tomatoes, corn, and improvement of potatoes by crossing and selection.

In investigations along the line of human nutrition, a thorough study was made of methods for determining sulphur dioxide in dried fruits. This study has indicated a number of points which have to be observed in obtaining reliable data from such investigations, and the information thus obtained may be considered a contribution to chemical methods.

The influences which affect the protein content of wheat were investigated. The findings of this study were that there are seasonal and varietal variations in protein content; that climate, particularly the amount of moisture in the soil, is the most important factor; that the protein content is not affected by allowing the grain to stand longer on the straw; and that retarding the growth of the wheat by lower temperatures increases the protein content. It was concluded, therefore, that the low gluten content of California wheats is not due to soil exhaustion, but to climatic factors and lack of selection.

In the department of animal husbandry a great variety of experiments were made with feeds for various domestic animals and with other matters connected with their management. Feeding experiments indicated that ground barley may be economically used as a supplementary feed with alfalfa for cows, and that great economy

results from the use of corn silage as a supplement to alfalfa. Studies were also being made on the metabolism of fresh milch cows, on the effect of alfalfa as exclusive feed for dairy cows and heifers, on the efficiency of milking machines, on the value of grains as feed for goats, and on the use of supplemental feeds in pork production.

The long-continued study of humus in California soils has shown that in so far as the humus content of these soils is concerned the soil proper may be considered as occupying the upper 3 feet. Some humus is found, however, down to a depth of 12 feet or more. The highest percentage of humus was found in the surface 3 feet, but as much as 0.74 per cent was found in the 13th foot in the soils near Davis. The average content of nitrogen in the humus of the first foot of soil was about 6 per cent.

The following publications were received from this station during the year: Bulletins 240, Commercial Fertilizers; 241, Vine Pruning in California, Part I; 242, Humus in California Soils; 243, The Intradermal Test for Tuberculosis in Cattle and Hogs; 244, Utilization of Waste Oranges; Circulars 103, Chemical Analyses of Waters; 104, The Amended Insecticide Law; 105, Analyses of Insecticides for Users; 106, Directions for Using Antihog-cholera Serum; 107, Spraying Walnut Trees for Blight and Aphis Control; 108, Grape Juice; 109, Community or Local Extension Work by the High School Agricultural Department; 110, Green Manuring in California; 111, The Use of Lime and Gypsum on California Soils; 112, The County Farm Adviser; 113, Announcement of Correspondence Courses in Agriculture; 114, Increasing the Duty of Water; 115, Grafting Vini-fera Vineyards; 116, Silkworm Experiments; 117, The Selection and Cost of a Small Pumping Plant; and The Annual Report for 1913.

The income of the station for the past fiscal year was as follows:

|   |                |
|---|----------------|
| United States appropriation, Hatch Act----- | \$15,000.00    |
| United States appropriation, Adams Act----- | 15,000.00      |
| State appropriation-----                    | 150,000.00     |
| Sales-----                                  | 5,000.00       |
| Fees-----                                   | 8,000.00       |
| Miscellaneous-----                          | 12,409.96      |
| <br>Total-----                              | <br>205,409.96 |

The generous appreciation which the station has received from the State authorities and the farmers of the State, resulting in liberal State appropriations, enables the station by means of its increased staff and large number of substations scattered throughout the State to study at first hand nearly all the agricultural problems which are pressing for solution and to come into direct contact with a large percentage of the farming population and with the practical as well as scientific problems which have arisen.

## COLORADO.

Agricultural Experiment Station, Fort Collins.

C. P. GILLETTE, M. S., Director.

Some of the new lines of work which had been planned for the year were greatly handicapped by the failure to secure the State appropriation until after a special session of the legislature, which was too late for some of the work. Nevertheless satisfactory progress was made along the old lines of investigation. E. R. Bennett resigned as horticulturist, and his place was filled by the appointment of E. P. Sandsten. A canal for use in rating meters was constructed in connection with the hydraulic laboratory, and a new soils laboratory was completed.

*Adams fund projects.*—A systematic study was devoted to the problem of the softness of Colorado wheats. Plat experiments with varying amounts of nitrate of soda, potash, and phosphorus yielded results which were believed to require confirmation by pot experiments in laboratory work. In this study analyses were made of the wheat plant and grain for amids, nitric nitrogen, total nitrogen, and moisture in all stages of growth.

From a study of the fixation of nitrogen in Colorado soils it is concluded that these soils are not unusually rich in nitrogen; that the nitric nitrogen does not arise from the same sources as ordinary white alkalis by decomposition of minerals; that the distribution of nitrates can not be accounted for by the assumption of concentration of preexisting nitrates; and that in soil patches in which the ratio of the total nitrogen is high the nitric nitrogen is due to fixation from the air.

An investigation of the nitrifying efficiency of some Colorado soils showed that as compared with soils from other States the Colorado soils were superior in nitrifying power. The highest gains in nitric nitrogen were produced from ammonium sulphate and the lowest gains from dried blood. The existence of nitrates to excess was found not to interfere greatly with nitrification, provided the chlorine content of the soil was low. The results obtained in these studies indicated that the nitrifying flora of Colorado soils is different from that in most soils from outside sources, or at least that the organisms concerned have developed distinct strains.

In investigating some peculiar brown spots on the surface of soils in various localities in the State it was found that these spots were very rich in nitrates and were actually toxic to trees and other plants. The nitrates were apparently formed in situ and the brown color appeared to be due to the solution of the pigment of *Azotobacter chroococcum* by the soil water.

The irrigation work of the station involved, as in previous years, a number of technical investigations. A study was made of frictional resistance in artificial waterways during which it was determined that the multiple-point method, whereby the velocity of the water is obtained by holding the meter successively at points relatively close together in a vertical plane, gave the closest determination of the actual mean velocity. This method is believed to be particularly rapid where reasonable accuracy is desired in a comparatively short time. Two other methods were found to be still more rapid but less accurate. In one of these methods velocity measurements were taken at 0.2 and 0.8 of the depth of water at each station and using the average as the actual velocity, while in the other method it was assumed that the average velocity of the water is that found at 0.6 of the depth of the water from the surface.

Experiments on the construction of weirs have been actively continued and much dependence is placed upon the efficiency of a new canal for rating meters in standardizing water meters. Among other irrigation investigations were experiments with the flow of water, drainage factors in farm crops, and the water requirements of crops.

The entomological project which received the most attention during the year was the study of plant lice, particular attention being given to the beet-plant louse which apparently spends a part of its life on the cottonwood. There has been some controversy as to the possible identity of the plant lice occurring on the elm and apple trees. The evidence obtained at the Colorado station was in favor of considering them distinct species.

*Work with Hatch and other funds.*—In spite of the delay in securing State aid much progress was made in various lines of work under the support of Hatch and other funds. The animal husbandry section collected some interesting data on the cost of beef production under semirange conditions. It was found that there was no profit in raising yearling feeders and turning them upon the market as feeders. All profit obtained from such animals was credited to the fattening of the steers as yearlings. The average cost of producing yearling steers under semirange conditions was \$28.38.

On a basis of two years' work it was concluded that there is material saving in the cost of feeding lambs where self-feeders are used for alfalfa hay. A good quality of barley proved equal to corn pound for pound for fattening lambs when used with alfalfa hay as roughage. With good quality of alfalfa hay the use of the feed cutter was found not to be economical unless the cost of cutting could be kept under \$1 per ton.

Selected tankage proved to be an exceedingly valuable feed for hogs when added to a grain ration at the rate of one part tankage to six to nine parts barley. Even fertilizer tankage was found to be

very satisfactory as a pig feed if carefully protected from contamination with hog cholera. California feed barley showed results inferior to those obtained with a plump brewing barley. Rye alone proved to be unpalatable for pigs. Alfalfa meal seemed to give the best results when fed to pigs weighing not less than 100 pounds.

The entomological section carried on considerable work on the study of the life history and remedies for the codling moth and on the syrphus flies, particularly in their relation to plant lice.

Along horticultural lines experiments were being carried on to learn what are the most hardy stocks for apples in Colorado and the factors which determine successful pear growing in the eastern part of the State. Practical studies were also begun in the management of niter soils in orchards. A general survey was made of the status of small fruit growing in Colorado, during which much practical information was obtained regarding the fungus diseases, insect pests, and cultural requirements of these crops. A similar survey was made of onion growing in the State. The experience of some of the best onion growers indicated that the cost per acre of producing onions in Colorado is about \$175.

Work in breeding wheat, barley, and rye was concerned largely with a study of the correlations of characters. Various crosses have been made between the second and third generations, and the segregations thus far worked out are remarkably close to the theoretical Mendelian ratios. In a continuation of the work on alfalfa the Baltic and Grimm types gave the best results, both at Rocky Ford and at Fort Collins. A study was also made of the relation between root branching and frost injury to alfalfa. In the eastern part of the State seed production has proved more profitable than growing alfalfa for hay.

The veterinary section confined its efforts largely to a study of brisket disease in cattle, methods of controlling hog cholera, and necrotic stomatitis of calves, sheep, and pigs. The last-named disease had become rather serious and required drastic measures of control. Data were also accumulated on the poisonous effect of certain plants, particularly the larkspurs.

In the horse-breeding project, carried on cooperatively with this department, much encouraging progress was made during the year. The total number of animals in the experiment at one time during the year was 90, of which 21 were discarded, leaving an excellent foundation stock with which to continue the experiment.

The following publications were received from this station during the year: Bulletins 186, The Fixation of Nitrogen in Colorado Soils; 187, Feeding Experiments with Lambs, 1908-9, 1909-10, 1910-11; 188, Ration Experiments with Swine, 1908-1911; 190, Variation Studies in Brome Grass; 191, Alfalfa Seed Production; 192, Home-

made Cider Vinegar; 193, The Nitrifying Efficiency of Certain Colorado Soils; and 194, Frictional Resistance in Artificial Waterways.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act | \$15,000.00 |
| United States appropriation, Adams Act | 15,000.00   |
| State appropriation                    | 10,301.87   |
| Miscellaneous                          | 7,696.86    |
| Total                                  | 47,998.73   |

During the year investigation was actively carried on in irrigation, soils, entomology, bacteriology, and agronomy, and in all of these lines results were obtained which will be of immediate use in building the foundations of continuously profitable agriculture in Colorado.

#### CONNECTICUT.

**The Connecticut Agricultural Experiment Station, New Haven.**

E. H. JENKINS, Ph. D., *Director.*

The work of the station underwent no change either in policy or in the lines of investigation. The arrangement with Yale University and Carnegie Institution for a cooperative study of proteid bodies was continued. The station received for the biennium \$65,500 from State appropriations, of which \$39,500 was for general maintenance, \$5,000 for foodstuffs control, \$8,000 for entomology, and \$13,000 for forestry, including \$2,000 for the purchase of land.

*Adams fund projects.*—The prosecution of the Adams fund project relating to protein research yielded some interesting results. The nutritive deficiencies of the proteins of corn and wheat were shown to be due to their lack of certain amino acids yielded by most other proteids. The addition of these amino acids to the diet supplemented the defective proteins and rendered them adequate for maintenance and for the promotion of normal growth. It was found possible also to supplement the deficiencies by replacing a part of the defective protein in the diet with another protein containing the lacking amino acids. The experiments showed that the value of a protein in promoting growth is determined by the quantity of that amino acid essential for growth which is present in least quantity in the food protein.

The results of the experiments were applied to combinations of commercial feeds rich in protein for the purpose of discovering the most economical proportions to be used for promoting the normal rate of growth. In this work it was found that a relatively small proportion of milk albumin rendered corn gluten adequate for growth. It was further discovered that if lard, olive oil, or almond oil constitutes the sole fat of the diet, growth ceases in white rats

after 80 to 100 days. They then rapidly decline and die unless a change is made in the diet. If, however, a part of the fat in the inadequate diet is replaced by butter fat, recovery takes place at once and normal growth continues. Cod-liver oil or the fat of egg yolk produces the same result.

In studying the improvement of corn in yield and feeding value the general plan of the work involved the determination of the best varieties from which selection was made and the investigation proceeded with first generation hybrids. High and low protein corn obtained in Illinois was crossed with ordinary strains of Connecticut corn. The results showed that low protein was a dominant factor, the hybrid possessing only the same protein content as ordinary Connecticut corn. The study of xenia in corn was continued in selection experiments in the mosaic color pattern with dent, pop, and flint corn varieties. The selection of light and dark colored patterns was pursued for several years during which the strains were purified and then crossed to determine the behavior of the character in transmission. In this work about 1,000 hand pollinations have been made.

Dry weather interfered somewhat with the tobacco-breeding investigations. The crosses of Cuban and Havana tobaccos showed purity of breeding and a greater number of leaves of a better shape than did the pure Havana type. For the purpose of determining the leaf shape, the eighth and twentieth leaves on the stalk were studied. It was found that the number of leaves per plant is a stable character little affected by changes in environment. The inheritance of quantitative characters such as size, shape, and number of various organs appeared to be due to the interaction of a multiplicity of factors which are inherited separately. A mutant tobacco plant of unusual height and with a large number of leaves was found which produced considerable seed. About 5,000 plants were grown from this seed and all of the plants were true to type.

*Work with Hatch and other funds.*—All departments of the station carried on work with the support of Hatch and other funds. The botanical investigations included a study of potato scab with reference to the use of fertilizers, a study of clubroot, chestnut blight, mosaic disease of tobacco with reference to the relative immunity of different types, black knot of cherry, onion smut, powdery scab of the potato, peach yellows, downy mildews, rusts, and spraying experiments with various fungus diseases. No satisfactory method of controlling the chestnut-bark disease has been found. The presence of the disease in a chestnut grove is not considered a sufficient reason for cutting out the trees, since they will make some growth even if infected and remedies are inefficient. The basis for the opinion that chestnuts from infected trees might be

injurious or dangerous was investigated without connecting the fungus of chestnut blight with the apparent poisonous effects noted. Cultures of the chestnut-blight fungus were eaten without harmful effects. It appeared that infected trees might possibly produce more immature nuts than healthy trees.

The chemical department had charge of control work involving the analysis of about 700 samples of fertilizers, 300 samples of feed, the inspection of creamery glassware, and to some extent the enforcement of the food and drug law, including all chemical work for the State dairy and food department. The enforcement of the State vinegar law was also under the auspices of the chemical department.

The forestry department of the station made a forest survey of the State showing the occurrence of forests on about 50 per cent of the area of the State. Experiments were also carried on with forest plantations, mostly of pine, on sandy bottom land near the Connecticut River. Information was also collected on the growth and hardiness of catalpa and on the economic importance of gray birch, hickory, Douglas white fir and other Western conifers which were imported for this purpose. A beginning was made in the investigation of willow culture, involving a study of five species of willows.

The entomological work included a study of apple-tree tent-caterpillar, lady beetles, brown-tail moth, gipsy moth, insecticides, and miscellaneous insect pests of vegetables, fruits, and forest trees. A survey was made of the present status and distribution of gipsy moth and brown-tail moth and much scout work and other insecticide operations were carried on in the control of these pests. In experiments on the cabbage root maggot, good results were obtained from the use of tarred-paper disks and carbolic acid emulsion as well as from lime-sulphur sludge. The application of lime-sulphur sludge gave encouraging results in preventing the attacks of peach and apple-tree borers and in reducing injury from rodents. Arsenate of lead was effective in controlling the hickory barkbeetle. An effective means of fighting the white-pine weevil was found in jarring the branches and capturing the weevils in nets. The entomological department was also in charge of nursery inspection which includes the annual examination of 60 nurseries in the State with their total of 1,400 acres devoted to the growing of nursery stock. Foreign nursery stock was inspected in cooperation with the Federal Horticultural Board.

In addition to the work in corn and tobacco breeding in connection with its Adams fund projects the department of plant breeding co-operated with the Storrs station in making a corn survey of the State to determine the best varieties of corn for silage and grain. Experiments were continued to discover the effects of self-fertiliza-

tion and cross-fertilization of cucumbers and tomatoes. A great increase in rapidity of growth of the first generation crosses between catalpa species has been demonstrated and is under study. Some selection work is also carried on with muskmelons, soy beans, and alfalfa.

The following publications were received from this station during the year: Bulletins 177, The Apple-tree Tent-caterpillar; 178, The Chestnut Bark Disease (*Endothia gyroza parasitica*); 179, Soy Beans; 180, Studies on the Tobacco Crop of Connecticut; 181, Some Common Lady Beetles of Connecticut; 182, The Brown-tail Moth; Forestry Publication No. 9, Connecticut's Forest Taxation Law; and the Annual Report for 1913, parts 1-6.

The income of the station during the past fiscal year was as follows:

|   |               |
|---|---------------|
| United States appropriation, Hatch Act-----     | \$7,500.00    |
| United States appropriation, Adams Act-----     | 7,500.00      |
| State appropriation-----                        | 26,875.00     |
| Individuals-----                                | 10,200.49     |
| Fees, including balance from previous year----- | 9,635.72      |
| Farm products-----                              | 7.98          |
| Miscellaneous-----                              | 46.98         |
| <br>Total-----                                  | <br>61,766.17 |

The work of the Connecticut State station as a whole shows a due consideration of both scientific and practical demands. It is believed that the fundamental investigation of proteins has reached the point where the results may be practically applied in compounding rations for farm animals.

Storrs Agricultural Experiment Station, Storrs.

E. H. JENKINS, Ph. D., *Director.*

The Storrs station, in cooperation with the Connecticut State station, at New Haven, is carrying on a corn survey of the State to determine the best types of corn for silage and grain and to test these types further as a basis for developing a supply of seed corn to be improved by selection and supervision. The third international egg-laying contest was carried out under the supervision of the college and station. E. B. Fitts, assistant in dairy husbandry, resigned, and was succeeded by H. F. Judkins. A laboratory building for use in soil biology was completed during the year. The incubator plant was improved and rearranged, and buildings for the dairy department were completed.

*Adams fund projects.*—The investigation of soils included the study of various forms of *Actinomyces* in soils, with reference to their number and species. Special cultural methods had to be de-

vised for the study of these organisms. Considerable attention was given to the bacterial life of frozen soils, and to bacterial development which takes place in frozen soils, with special reference to the behavior of the soil film under these conditions. It was found that the number of bacteria increases about 10 times from fall to the time when the ground is frozen. In this connection observations were also made on soil temperatures.

Decided progress was made in the study of bacillary white diarrhea of young chicks. It appeared that female chicks infected with *Bacillus pullorum* may develop into permanent carriers of the bacillus and may be constant sources of danger to other fowls. The disease carriers in a flock of poultry may include 25 per cent of the whole flock. The agglutination test for diagnosis of white diarrhea proved to be thoroughly reliable. About 6,000 fowls were tested in this way for private owners. In this work the disease was found in almost every flock, affecting 40 per cent of the birds in some cases. Evidence was obtained that the male birds may also be carriers of the disease. Feeding sour milk had a most beneficial influence on the growth of chicks, lessening mortality from white diarrhea as well as from other diseases. For this purpose ordinary sour milk proved to be as effective as milk soured with cultures of *B. bulgaricus*. In the general project on the bacteriology of eggs, particular attention was given to the study of the effect of different amounts of carbon dioxid in the air of incubators. Evidence was obtained that unless carbon dioxid exceeded 60 parts in 10,000 in incubators no injurious effects were noticed on the hatching of the eggs. In fact, the effect was only slight when carbon dioxid occurred in 150 parts per 10,000. It appeared that in all of the good types of incubators, properly managed, the amount of carbon dioxid never passes the danger point. The chief source of carbon dioxid in the air of incubators was found in the embryo. The gas increases from the beginning to the end of the period of incubation with the exception of a slight diminution for the first and sixteenth days. The amount of carbon dioxid under sitting hens at the beginning of the period of incubation was found to be much higher than that in the room, and increases to 50 parts per 10,000.

The study of foreign types of cheese was completed and the results from the investigation of Roquefort, Camembert, and Neufchatel cheeses were published. The bacterial flora of Roquefort cheese was found to include the Roquefort mold, lactic bacteria, certain liquefying organisms, and a few yeasts. By the use of paraffin, *Oidium lactis* and some of the slime bacteria were eliminated, showing that the ripening of the cheese did not depend upon these organisms. The dominance of Roquefort mold in the cheese was secured by the low oxygen content of the open spaces and of the high salt content. To

obtain a smooth, friable curd, free from granular structures and toughness, the initial acidity should not pass 0.23 per cent. In making Camembert cheese the following conditions were found essential: A room temperature of 70° F., a relative humidity of 85 to 90 per cent, a milk containing not more than 0.5 per cent fat, and the use of a lactic starter. It was found possible to prepare a Roquefort cheese from cow's milk which is a satisfactory cheese in every respect and a profitable product for dairy manufacturers, but which differs slightly from Roquefort made from sheep's milk.

*Work with Hatch and other funds.*—Several lines of work were carried on under the support of Hatch and other funds. A feeding test with young chicks in which sour milk was included in the ration yielded results indicating that sour milk hastens development to the extent of about one month. Careful weighings and other observations were made on the depressing effect of lice in the development of chickens, and experiments were begun in developing practical methods of controlling these pests.

The dairy work of the station included a study of the cost of milk production, the effect of variations in speed and cream separators as modified by temperature and mechanical adjustment of the separator, and a number of minor feeding experiments for dairy cows. Bacteriological studies of ice cream were made, and a test was carried out in which commercial lactic starters were compared with ordinary methods of starting cream.

The chief work in agronomy was conducted on a 20-acre tract of experimental plats. Three rotation tests with dairy forage were begun, the crops being grown on one-tenth acre plats, six in a series, and the rotations being devised for four and five years' duration. Plans were also made for variety tests in connection with the rotation experiments, as well as for corn breeding, hill selection of potatoes, the cultivation of root crops, soy beans, alfalfa, wheat, and rye.

The publications received from this station during the year were as follows: Bulletins 75, The Bacteriology of the Hen's Egg, with Special Reference to Its Freedom from Microbic Invasion; 76, Carbon Dioxid in Incubation; and 77, Bacillary White Diarrhea of Young Chicks (Fourth Report).

The income of the station during the past fiscal year was as follows:

|   |            |
|---|------------|
| United States appropriation, Hatch Act-----                       | \$7,500.00 |
| United States appropriation, Adams Act-----                       | 7,500.00   |
| State appropriation, including balance from previous<br>year----- | 4,852.56   |
| Miscellaneous, including balance from previous year-----          | 3,249.34   |
| Total -----   | 23,101.90  |

The researches of the Storrs station added largely to a sound basis for improved methods of specialized farming, and the demonstration work called wide attention to the activities of the station, thus bringing the staff into closer contact with the farmers.

#### DELAWARE.

**The Delaware College Agricultural Experiment Station, Newark.**

H. HAYWARD, M. S. Agr., *Director.*

The efforts of the Delaware station were devoted to the same lines of work as in previous years. The work of the station brought it into closer contact with farmers than had ever been the case, with beneficial results to the station in the more sympathetic attitude of the farmers. A greenhouse was constructed during the year for the exclusive use of the station. There were no important changes in the staff.

*Adams fund projects.*—Decided progress was made in the projects carried on by the support of Adams funds, and results of importance were brought forth from nearly all of these studies. An investigation of the composition of fruit juice indicated that the average molecular weight of the solids of fruit juices increased toward the maturity of the fruit. It became evident, however, that there are bodies of low molecular weights formed along with the sucrose and counterbalancing to some extent the effect of the sucrose. Except in the case of the strawberry, the osmotic pressure of the fruit juice increased up to the final stages of ripeness. Considerable progress was made in working out a method for determining fruit acids when occurring together. During the coming year it is hoped to trace the changes which occur in sugar, starch, and acid contents of fruits.

In a chemical study of lime-sulphur solutions it was found that these solutions consist principally of pentasulphid and thiosulphate of calcium. When the ratio of lime to sulphur was 1 to 2.25 the preparation was found to consist of pure calcium pentasulphid and calcium thiosulphate. When the proportion of lime was greater than that expressed by the ratio of 1 to 2.25 oxysulphites and hydrosulphites were formed and free lime appeared in the solution. The presence of magnesia proved to be without effect except as a diluent of the lime. Self-boiled lime-sulphur solutions differed from concentrated preparations chiefly in containing a large amount of free lime in solution.

Interesting results were obtained in the study of the function of nitrogen with potassium and phosphorus in the growth of the peach and apple. That portion of the work which was carried on in concrete pits suffered on account of the fact that the trees in that location

were more subject to frost than those in the field and the fruit did not grow satisfactorily. The value of nitrate of soda as a fertilizer for peach orchards was brought out quite strikingly, economic results being obtained from applications as high as 1,000 pounds per acre. Phosphoric acid was found to be of least importance in fertilizing peaches. Apparently the pollination was defective in the presence of an excess of phosphoric acid and a poor set of fruit resulted.

The station's study of the diseases of the sweet potato was practically completed. Three forms of black rot of the sweet potato were distinguished, one due to *Selerotium bataticola*, and called the charcoal rot of the sweet potato to distinguish it from the ordinary black rot, while the third form of black rot was found to be due to *Lasiodiplodia tubericola*. Work was continued on a bacterial disease of legumes. This disease affects a number of species of legumes and was found to be due to *Bacillus lathyri*, first recognized and described by the station. A number of sweet potato diseases in addition to the black rots received attention, as well as the conditions which are necessary for satisfactory storage of sweet potatoes. Apparently the moisture content of a cold-storage room is of more importance than the temperature.

In the station project on soil bacteriology attention was devoted to four types of soil. No pronounced diminution in the beneficial type of bacteria was observed in soils which showed a high lime requirement. It appeared, therefore, that many crop plants are more sensitive to soil acidity than is the bacterial flora of the soil. A fungus was found in Norfolk sand soil which may prove to have the power of fixing nitrogen.

The research work of the department of animal husbandry was confined to a study of the effect of close inbreeding with cattle and swine and to a less extent with sheep. The most conclusive results were obtained with swine. It was found practically impossible to carry on breeding when the animals contained more than 75 per cent of the same blood. This degree of inbreeding was obtained in the fifth generation. No deleterious effects were observed from inbreeding hogs to the extent of 75 per cent of one strain of blood. A check on still further inbreeding appeared, however, in an increase of sterility and abortion. With cattle of the Guernsey breed, inbreeding has been carried thus far only to the extent of 60 per cent of the same blood as measured by the formula proposed by Dr. Pearl. Poor success was had with the inbreeding experiments with sheep.

In the department of agronomy, important results were obtained in studying the relation of the physical characters of ears of corn and types of kernel and the vigor of the plant. Judging by the data

thus far obtained, rather clear indications are looked for as to the type of ear which should be selected for planting.

Progress was also made in the study of the effect of various forms of lime on the decomposition of the organic matter in the soil. It was found that phosphoric acid may be quite available for the first three months and potash inert, while later analyses of the same limed pots will show the reverse to be true.

The plant food requirements of different varieties of wheat were studied on plats of poor soil. The evidence thus far obtained indicates that the types of wheat which give a small yield take up proportionately less plant food than do the productive types. Apparently the bearded varieties have a better capacity for making use of fertilizers than the smooth types of wheat.

Some additional data were accumulated in the study of the preparation and application of autogenic vaccines for animal diseases. When virus from pus-forming bacteria and various infections was fed directly to horses, a stimulation of the production of antitoxin was apparently brought about. Further investigation of this point may be made.

*Work with Hatch and other funds.*—With the support of Hatch and other funds, a variety of work was carried on, particularly in horticultural and agronomic lines. An elaborate study was made on the subject of tomatoes for canning purposes with the result that a basis was obtained for specific recommendations regarding practically all of the cultural details connected with tomatoes raised as a canning crop. The evidence pointed to a sandy loam as an ideal soil for tomatoes, and tomatoes were found to require relatively little phosphoric acid and a large amount of potash. Stable manure was found best applied to another crop in rotation with tomatoes. The average cost of producing and marketing an acre of tomatoes in Delaware is shown to be about \$38. When yield alone was considered, the leading varieties of tomatoes for the past three years were Shallcross, Favorite, and Perfection, but the best canning varieties were considered as being Coreless, Delaware Beauty, and Magnificent. For a number of years experiments have been carried on with cover crops for peach and apple orchards. The value of oats and cowpeas as a cover crop for such purposes has been thoroughly established.

From tests of corn varieties quite definite hints were obtained as to the varieties which should be recommended for various localities in the State. Elaborate variety tests of wheat were carried on, with the result that for general adaptability as a class the bearded wheats appear superior to the beardless types. A difference of 6 bushels per acre as an average of six years was shown in favor of the bearded wheats. In variety tests with oats better results were obtained with

winter than with spring oats, but of the spring oats Silver Mine gave a satisfactory yield.

In cultural tests with soy beans, it was found that more seed can be obtained from sowing the beans as wheat is drilled than from sowing them in cultivator rows. Data have been accumulated for several years at the station on the limiting elements of plant food of various crops, particularly corn, wheat, clover, and soy beans. From the experiments thus far carried on, it appears that potash is an essential ingredient for corn and clover, particularly, while phosphoric acid is the limiting element for wheat.

The publications received from this station during the year were as follows: Bulletins 99; Soy Bean Oil; 100, Annual Report of the Director for the Fiscal Year Ending June 30, 1912; 101, Tomatoes for the Canning Factory; and 102, Fruit Juices.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act----- | \$15,000.00 |
| United States appropriation, Adams Act----- | 15,000.00   |
| Farm products-----                          | 11,101.00   |
| Total-----                                  | 41,101.00   |

The station is getting in closer touch with the farmer, its work is of high grade, and it deserves support by State funds in order to enable it to meet more fully the demands which come upon it.

#### FLORIDA.

##### Agricultural Experiment Station of Florida, Gainesville.

P. H. Rolfs, M. S., *Director.*

The Florida station experienced no important change in staff or policy during the year. Two notable features of the work of the station were its investigations concerning the citrus-fruit industry and its breeding experiments with velvet beans. The station continues to have its own equipment and staff separate from the teaching staff of the college, and this arrangement apparently leads to satisfactory work.

*Adams fund projects.*—The main work of the station for the year was on Adams fund projects. The study of soils and fertilizers in relation to plant growth was carried on in the experimental orange grove at Tavares and also in tanks at the station, the same series of fertilizers being used in both localities. In the tank experiments sufficient water was added to keep the water table within 7 inches of the surface in the first series and within 14 inches in the second, while in other series merely sufficient water was used to keep the soil moist. Careful records have been kept of the effect of the height of the

water table on the length and diameter of the stem and length and breadth of leaf. The different series of orange trees in tanks showed close correlation with types of growth obtained in orchards with similar soil conditions.

In order to collect information on a large scale as to the relation between soil and cultural treatment and the composition of oranges and grapefruits, analyses were made of over 500 lots of these fruits covering a whole season of citrus fruit. The analytical results showed that with oranges there was a gradual increase of total sugar toward maturity and a decrease of acidity, and that sucrose and reducing sugars increased at about the same rate. The same phenomena were observed in grapefruit, but to a less marked degree. The analyses indicated that the line of demarcation between fruit classified as sour and that classified as sweet lies near the ratio of 1 of anhydrous acid to 7 of sugar.

In the series of experiments in the growth of citrus seedlings in sand cultures it appeared that on the whole the best growth was obtained from a combination of acid phosphate and dried blood. As a source of nitrogen for citrus seedlings, nitrate of soda and nitrate of potash were of about equal value.

Definite progress was made in the study of nutrition as related to physiological diseases. Particular attention was given to nonparasitic gummosis as produced by chemicals. In these experiments an enzym and 28 different organic and inorganic chemicals were used by injection into the trees for the purpose of determining their effect on the formation of the gum. The most copious production of the gum was caused by copper sulphate and other salts of heavy metals. In these cases the injury extended from the point of insertion in the bud or stalk to the upper branches. Injury of this nature caused by other compounds was confined to the point of insertion and the amount of gum formed was much less. The formation of gum was studied in relation to die-back, experiments being carried on in the greenhouse. This disease apparently does not kill the plant, but weakens the tissues so that other diseases gain entrance. One of the symptoms of the disease is rank growth and the presence of an excess of organic and other forms of nitrogen has been partly connected with the occurrence of die-back.

In carrying on investigations of citrus diseases attention was given to citrus canker, gummosis, not of a physiological but presumably of a parasitic nature, melanose, stem-end rot, blight, etc. Citrus canker has been definitely shown to be distinct from citrus scab and due to a fungus not yet identified. The serious nature of the disease has led to unusually drastic control measures. Several fungi are apparently connected with the parasitic form of gummosis, which thus far has not yielded to cultural methods or application of specific

fertilizers. Excision of affected parts and painting with Bordeaux paste have yielded promising results. Other lines of treatment are being applied. The fungus cause of melanose has been pretty well established as being identical with that which produces stem-end rot. Spraying with lime-sulphur has been most effective in checking this disease.

Further progress was made in the study of entomogenous fungi. It was found that fungi which cause disease of white flies may be successfully preserved in dry storage. The woolly white fly recently appeared to an alarming extent, but was found to be heavily parasitized by native hymenopterous insects. The observational data on the life history of the woolly white fly have been practically completed. Six or more fungus parasites of white flies have been kept under observation and study. Some of them continued to act most effectively in controlling the white fly. The purple scale and white fly have been observed to be commonly associated, and a study is being carried on to determine the biological causes of this apparent association.

Considerable attention was given to velvet-bean caterpillars, with particular reference to the details of their life history. The most practicable remedy thus far found was in the use of early varieties, since in this way a large part of the injury may be avoided.

Active work was carried on in the breeding of hybrids between the Lyon and velvet beans. In this work a large amount of information was accumulated regarding the segregation and possible inheritance of characters in these hybrids. In this connection the interesting discovery was made that semisterility may occur in the hybrids and may become an inherited character. The random abortion of half of the pollen grains and half of the embryo sacs is believed to be due to the segregation of the Mendelian factors. In some of the hybrids between the Lyon and the velvet bean definite results have been obtained in the increase in earliness and yield. Apparently a Mendelian factor has been found determining long and short pods.

Interesting results have also been obtained in breeding corn. One strain of sweet corn has been secured which endures hot weather as well as does field corn. Breeding experiments with corn are also in progress to obtain if possible a more flinty corn, with the idea that it may be more immune to insect pests of corn.

*Work with Hatch and other funds.*—With the support of Hatch and other funds numerous lines of work were carried on, particularly in agronomy and animal industry. Pig-feeding experiments have engaged much of the time of the animal husbandman. Various rations have been compounded from Florida forage crops as suitable for fattening hogs. In one series of experiments corn and velvet beans were divided into various proportions, with the result

that the large gains were made from a ration containing three parts corn to one of cracked velvet beans. The cheapest gains occurred, however, when corn and velvet beans were fed in equal proportions.

In a study of milk production, experiments were instituted to gain evidence on the economy of dairying. The experiments gave rather exact data on the cost of milk production with home-grown feeds. The cost of producing a gallon of milk ranged from 12.7 to 15.6 cents. Under Florida conditions, it appeared that most profit was obtained from selling whole milk, next from selling cream, and least from selling butter.

Work with Japanese cane as a forage crop has been continued with promising results. Larger yields were obtained than with either corn or sorghum. Excellent success was had in ensiling cassava and sweet potatoes. Variety tests were also continued on sorghum, corn, and cotton, although root-knot infection interfered with the cotton experiments. During the year miscellaneous information was accumulated and published in bulletin form on lettuce drop, tomato diseases, cucumber rot, Irish potatoes, and syrup making.

The following publications were received from this station during this year: Bulletins 114, Milk Production, II; 115, Sugar and Acid in Oranges and Grapefruit; 116, Lettuce Drop; 117, Tomato Diseases; 118, Sugar Cane and Sirup Making; 119, Fungus Diseases of Scale Insects and White Fly; 120, Irish Potatoes in Florida; 121, Cucumber Rot; and 122, Citrus Canker, a Preliminary Bulletin.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act----- | \$15,000.00 |
| United States appropriation, Adams Act----- | 15,000.00   |
| Farm products-----                          | 1,565.69    |
| Balance from previous year-----             | 24.09       |
| Total-----                                  | 31,589.78   |

By reason of its well-directed efforts in attacking local agricultural problems the station has secured a strong hold on the people of the State. The results brought forth during the year were of great importance and of general interest.

#### GEORGIA.

Georgia Agricultural Experiment Station, *Experiment*.

R. J. H. DE LOACH, A. M., *Director*.

During the year notable progress was made in arranging the affairs of the station upon a more satisfactory basis. The work of the members of the staff was outlined more carefully and systematically in project form and with definite consideration of the problems which

are pressing most urgently for attention and solution. New barns were completed, feeding studies inaugurated, and a small appropriation from the State enabled the station to make some needed improvements of a general nature. Dr. B. B. Higgins was appointed as botanist, C. A. Wells as chemist, and C. K. McClelland as agronomist.

*Adams fund projects.*—The study of the balance of acid-forming and base-forming elements in the toxicity of cottonseed meal was conducted with Duroc-Jersey pigs 6 weeks old, which were fed different amounts of cottonseed meal, varying from 10 to 25 grams per kilogram of live weight. These preliminary experiments were made to determine the size of the lethal dose of cottonseed meal. In order to learn whether there was any basis for the theory of acidosis in cottonseed-meal poisoning, hydrochloric acid was fed to some of the hogs, but without effect.

Considerable progress was made in the study of the application of Mendel's law to hybrids between white and black varieties of Muscadine grapes. A correlation was found between the color of the fruit and the color of tendrils in young vines. When the white staminate plant was crossed upon a white pistillate plant the progeny were all white; but a black staminate crossed upon a white pistillate plant gave both black and white progeny, the black predominating in the first generation. A study will be made of the morphology of the pollen of the black and white varieties. In this work about 2,000 seedlings were had under observation.

In investigating the influence of a combination of feeds on the digestibility of the component feeds in a ration 13 steers were used, and the digestion periods were made 10 days in length, with a preliminary period of five days. From the study of digestion and metabolism on steers on a continuous ration of corn silage it appeared that animals on a low plane of nutrition did not more completely digest the food as the period of feeding progressed, but that the tendency was rather in the opposite direction. The retardation in the digestibility of the food in an animal after having been on a low plane of nutrition for a long time was believed to be due to the general retardation of the digestive functions. In the progress of a feeding experiment the diminution of the amount required for maintenance appeared to be due not to the ability of the animal to digest the food more thoroughly, but to its ability to use the food more economically. The water consumed in these experiments was greatly influenced by the moisture content of the foodstuff. The disposition and nervousness of the animal was found to be materially affected by being placed on a low plane of nutrition.

The effect of stable manure upon the bacterial flora of soils was investigated for the purpose of tracing the fate of the bacteria that are added to the soil with the manure and to determine the effect on

the general bacterial flora. The number of bacteria in the soil was found to be considerably increased by the use of manure, but it was not determined whether this increase was in any way due to the presence of the added species. In connection with this work the process of nitrification in acid soils was investigated. It appeared that when tankage, dried blood, peptone, asparagin, and other substances were acted upon by the soil organisms, ammonia was formed in excess of the acids produced, the ammonia neutralizing the acids present and allowing nitrification to proceed normally. In the progress of this work the question arose whether nitrification is in all cases a desirable process from the standpoint of soil fertility. It was found that ammonium sulphate in soils which admitted of little nitrification was more beneficial than an equal amount of nitrogen supplied as cottonseed meal, tankage, dried blood, or nitrate of soda. While it was not found that organic acids could not be formed and remain in arable soils, it appeared that the danger of injury to the soil from this source was very slight.

In a study of the nutritive media most suitable for the growth of *Pseudomonas radicicola* considerable difficulty was experienced in growing plants which did not develop nodules, and in preventing bacterial contamination of earthen pots. The work will be continued in large glass bottles. The investigation of the chemistry of the cotton plant has been prosecuted through a period of four years. Particular attention was given to a determination of the amount of constituents taken up by the cotton plant at four stages of growth. It was found that approximately one-third of the total plant food is taken up by the plant during the first 30 days of growth, the second third of the plant food was absorbed during the second period of 30 days, terminating with the formation of the first bloom. Of the total dry matter of the plant, however, only one-eighth was produced during the first period, another eighth during the second period, one-fourth during the third period, and one-half during the maturing period.

Considerable progress was made on the project inaugurated during the year for the study of the plum wilt organism. In this work a number of organisms were isolated and one fungus was found which appeared to produce wilt. This disease affects particularly Japanese plums and only rarely other varieties.

*Work with Hatch and other funds.*—Work carried on at the station with the support of Hatch and other funds was confined largely to the departments of horticulture and agronomy. A study of the blossom-end rot of tomatoes indicated that the cherry varieties of tomatoes are not subject to the disease. This variety will be crossed with larger varieties in the hope of producing disease-resistant strains of commercial importance.

The horticultural department investigated the culture and the storing of sweet potatoes, as well as fertilizers for use in improving the yield of this crop. It appeared that sweet potatoes planted between May 16 and June 11 gave larger yields than those planted either earlier or later. When the vines were cut off to about one foot in June the yield of potatoes was reduced nearly one-half. None of the disinfectants which was used proved efficient in preventing decay while potatoes were in storage. Nitrogenous fertilizers invariably produced large vines but did not always increase the yield of potatoes, and nitrate of soda when applied alone seemed to injure the quality of the potatoes. No relation was noted between the size of the starch grains in the sweet potatoes and the kind of fertilizers applied. Variety and cultural tests were conducted on nearly all of the common truck crops and the results of these observations were published in bulletin form. It was found that nitrate of soda delayed the ripening of watermelons and when applied in large amounts reduced the yield. Some effect was noted from fertilizers upon the color and quality of watermelons.

In a fertilizer experiment with cotton, a comparison was made of various sources of nitrogen. The largest yield was obtained from dried blood, followed by that on the plat which received cottonseed meal. This experiment was repeated using only dried blood and cottonseed meal for comparison with a basal fertilizer formula for both plats. The relative effect of dried blood and cottonseed meal was the same as in the previous experiment. A comparison of muriate of potash and kainit indicated the decided superiority of the muriate of potash. A test was made of the effect of dynamiting cotton land. For this purpose the charges were placed 15 feet apart each way, at a depth of  $2\frac{1}{2}$  to 3 feet, and at a cost of \$16.80 per acre. There was an increase of 126 pounds of seed cotton per acre in favor of the dynamited land.

In a series of experiments which were continued for a period of four years it was found that sulphate of ammonia was the best and cheapest source of nitrogen for corn on Georgia soils. Dried blood proved to be superior to cottonseed meal for this purpose. Apparently the fertilizing effects were more pronounced when the fertilizer was applied at the second plowing, rather than at the time when the corn was planted.

The publications received from this station during the year were as follows: Bulletins 103, Nitrification in Acid or Nonbasic Soils; 104, Corn Culture; 105, On Cotton Cultivation; 106, Vegetable Gardening; 107, Sweet Potatoes—Culture, Storing, and Studies in Fertilizing; and 108, The Feeding of Cotton; Circulars 69, Station Publications; 70, Cotton and Corn Variety Tests; and 71, Soil Nitrogen—Green Manures.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----               | \$15,000.00 |
| United States appropriation, Adams Act-----               | 11,640.17   |
| Balance from United States appropriation, Adams fund----- | 3,359.83    |
| State appropriation-----                                  | 706.45      |
| Farm products-----  | 4,209.16    |
| Balance from previous year-----                           | 4,586.77    |
| Total-----  | 39,502.38   |

Material improvement has been made in the Georgia station in personnel, equipment, and work. The atmosphere of the institution has changed for the better, and the energies of the staff are being directed in a way to achieve important results.

#### GUAM.

##### **Guam Agricultural Experiment Station.**

**JOHN B. THOMPSON, B. S., *Special Agent in Charge.***

The year was marked by unusually favorable climatic conditions in Guam. The lines of work already undertaken at the station were continued and a great increase was noted in routine work. Dr. L. B. Barber was appointed as veterinarian and animal husbandman. The special agent in charge resigned at the close of the year and Mr. A. C. Hartenbower was appointed in this position at the beginning of the coming fiscal year. An addition was made to the station barn to furnish better accommodations for the live stock. Considerable attention was given to methods of protecting the library against mildew in the rainy period. This has been fairly well accomplished by the use of sectional cases. A stock farm of 1,200 acres was added to the equipment of the station.

Good yields of cucumbers were obtained, but this crop was found to be less successful in the period from April to July. Okra gave excellent results during the whole dry season, and satisfactory yields were also obtained with eggplants, peppers, lettuce, radishes, carrots, beans, and tomatoes. The naval authorities of the island are interested in the development of subsistence agriculture which would supply the necessary food for the inhabitants in time of possible blockade. The results thus far obtained along that line by the station have been promising. Tomatoes were affected with so many serious troubles that little success was had from them until during the year under report. A variety has at last been obtained which proved well worthy of cultivation and has given high yields. An experiment was made in propagating tomatoes by cuttings. This proved quite successful, and at the close of the year a fair crop of

fruit was obtained. It is believed that the station will be able to produce its own supply of tomato seed.

Work with mangoes has been continued. A number of inarched plants were distributed about the island. It has been found that fruit has borne within a remarkably short period on inarched mangoes, in one instance within less than a year from the time of inarching. The station had an interesting experience with an old mango tree which had to be transplanted. Although the tree was 33 inches in circumference, the transplanting offered little difficulty, and new foliage appeared within two months.

Among the various forage crops which have been tested at the station the most promising results are reported with Para grass, *Paspalum dilatatum*, sorghum, and peanuts. The Para grass is used largely for soiling purposes, but has also been utilized as a pasture grass. Guinea grass has been found to be inferior to either Para grass or *P. dilatatum* on the island. The yield obtained from Spanish peanuts was entirely satisfactory. On the basis of this year's experiments the hope was expressed that the peanut will become an important forage and food plant in Guam.

The increased interest manifested by the inhabitants of the island in honeybees was gratifying. The station apiary included 32 colonies. Modern methods of handling bees have been demonstrated to visitors in the apiary. Already 12 interested persons have gone into the bee business with modern equipment secured through the advice of the station. The supply of honey plants on the island is believed to be sufficient for the production of all the honey required for local use and to offer small quantities of both honey and wax for export.

Fortunately the list of serious animal diseases in Guam is rather small. During the year the attention of the animal husbandman was devoted chiefly to breeding of horses, cattle, pigs, goats, and chickens. The crossbred horses from Morgan sires and native mares have been found to inherit quite largely from the superior quality of the sire. These encouraging results indicate that more attention will be given by the inhabitants of the island to the improvement of horses. Attention was also given to the control of the common mawworm of horses, hoof cracks, and tetanus.

The Ayrshire bulls belonging to the station were called upon for rather wide service with native cows. All imported cattle have proved subject to attacks of fever at various times. In one or two instances of death among these cattle the lesions characteristic of Texas fever were found. Immunization of susceptible cattle from the United States by the method of controlling tick infestation has not thus far proved reliable. The method has resulted in the appearance of a chronic form of the disease. The tuberculin test on the station cattle showed no reaction.

The most encouragement in the line of animal breeding has been received from work thus far carried on with hogs. The Berkshire has been used to improve the quality of the scrub pigs of the island. During the year the station came into possession of a small herd of goats, some of which have inherited the blood of a strain of Japanese milch goats resembling the Toggenburg breed. The goat has been found to adapt itself without trouble to the climate of Guam and it is believed that it may furnish an economic source of milk to some of the inhabitants of the island.

The attempt to improve the poultry of the island has been continued by the introduction of pure-bred Plymouth Rocks and Brown Leghorns. The native fowls have proved to be unusually hardy and crosses between the native fowls and pure Plymouth Rocks and Brown Leghorns showed a tendency to increased hardiness over that of the pure breeds.

The annual reports for 1912 and 1913 were received from this station during the year.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation                 | \$15,000.00 |
| Sales, including balance from previous year | 361.05      |
| Total                                       | 15,361.05   |

The problem of making the island self-supporting from an agricultural standpoint has been accepted by the station as its most important duty and marked progress in that direction was reported during the year.

#### HAWAII.

*Hawaii Agricultural Experiment Station, Honolulu.*

E. V. WILCOX, Ph. D., *Special Agent in Charge.*

The main energies of the station, as in previous years, were devoted to a study of various problems which have arisen in Hawaiian agriculture. The substation work received more attention than heretofore, and a new line of work was inaugurated in assisting the marketing of farm products. The territorial legislature provided the funds for marketing work. There were no staff changes during the year. The Public Health and Marine Hospital Service turned over 7 acres of its land adjoining the station grounds for the use of the station in agricultural work for an indefinite period. This land will be used in part in experiments to determine the relative green-manuring value of various legumes.

The work of the marketing division organized July 1, 1913, was inaugurated to meet actual conditions and grew as necessity required. Farm produce sent to Honolulu was received and sold at

wholesale, lists of breeders of fine stock were prepared and distributed to all interested farmers, and market quotations of prices of all farm produce sold in Honolulu were distributed throughout the Territory weekly, in order to give information on the demands of the market and the amounts which could be sold and prices which could be expected from week to week. In order to facilitate the work of the marketing division, various communities of farmers were organized in cooperative associations, each with a selling agent to deal directly with the marketing division. During the year the monthly sales increased from \$84 to \$6,000.

At the Greenwood substation further experiments were carried on to determine the best forage crops for dairy cows under the extremely heavy rainfall that prevails in that locality. Para grass and *Commelina nudiflora* were found to be the best forage crops. A silo was erected in which Japanese cane and Para grass were preserved as cattle feed. No difficulty was experienced in making excellent silage of sugar cane. At the rubber substation in Nahiku further studies were made on the culture of roselle, about 200 acres of this crop being planted during the year.

In a study of soils it was found that in heavy clay all fertilizers checked the movement of soil moisture in all directions. Nitrate of soda had the effect of increasing the water-holding power of such soils. Lime and magnesium salts were found to check percolation in soils much less than salts of sodium, potassium, and ammonium. Repeated experiments showed that phosphoric acid is fixed by Hawaiian soils to a greater extent than other fertilizers. This fertilizer was found most effective when applied in a soluble form, but since it is not leached from the soil it remains available at least for three or four crops after application. As a result of further study on the lime-magnesia ratio, it appeared that this ratio is not important unless one or the other salt occurs in a soluble form to excess. Additional evidence was accumulated on the unusual importance of aeration in Hawaiian soils. Otherwise no nitrification was found to occur.

Analyses were made of nearly all of the common tropical fruits in a ripe condition, and a systematic study was carried on with the ripening process in bananas and papayas. The possibility of applying cold storage to tropical fruits was also investigated, with results indicating that avocados may be safely held at a temperature of 32° F. for a period of two months or more and other tropical fruits for corresponding periods.

A variety of Japanese rice, known as Bezembo, was obtained which matures about 10 days quicker than any other variety at the station and was better liked by the Japanese population than previously imported Japanese rices. The fourth crop was taken from a meas-

ured acre of Caravonica cotton which had been pruned back after each picking during the past four years. The crop yield was 418 pounds of lint, which is only slightly less than the yields for the second and third years. The experiments were continued with about 70 species of soiling and pasture grasses from which the most promising results during the year were obtained with Giant Bermuda and Sudan grasses. Flax made a fine growth on the station grounds, yielding 18 bushels of seed per acre. Buckwheat has proved a satisfactory crop to raise for chicken feed.

In the work with papayas a study of 500 trees of the second generation showed that 95 $\frac{1}{2}$  per cent of these trees were fruit-bearing trees with perfect flowers. The attempt to establish a strain of papayas with self-fertile flowers and with the male trees eliminated therefrom promises some success. Data were accumulated on the bearing age of seedling, budded, and inarched mangoes and avocados.

Among the miscellaneous results of the station work were a great increase in the algaroba meal industry, the organization of a company to produce kukui oil, the general adoption of arsenite of soda spray for weed destruction, and the institution of a system of rotation for cane growing. The demand for leguminous cover crops for this purpose on the part of cane growers became so large that a special industry has developed among small farmers located adjacent to cane plantations in growing Jack bean and other leguminous seed for the use of the cane planters.

A study was made of the chemical composition and flavor of coffee from coffee cherries infested and not infested with the fruit fly and from ripe and partly ripe cherries. It was found that the chemical composition was not affected by infestation with the fruit fly and that the flavor of coffee from nearly ripe cherries was slightly superior to that from fully ripe cherries. An experiment was made to test the value of rat virus in destroying rats in the open field. The results seemed to be promising, since the disease persisted among the rats during the whole year. The unusual prevalence of the hen flea led to experiments to furnish means of controlling this pest. It was found possible to destroy it by means of a 3 per cent solution of carbolic acid in glycerin or by kerosene oil.

The following publications were received from this station during the year: Bulletins 29, Ornamental Hibiscus in Hawaii; 30, The Effect of Heat on Hawaiian Soils; 31, Rice Soils of Hawaii—Their Fertilization and Management; 32, The Papaya in Hawaii; 33, The Organic Nitrogen of Hawaiian Soils; 34, Tobacco Insects in Hawaii; Press Bulletins 42, Corn Culture and Improvement; 43, Eye Worm of Chickens; 44, Plantation Rubber in Hawaii; and 45, An Experiment in Marketing under Territorial Auspices; and the Annual Report for 1913.

The income of the station during the past fiscal year was as follows:

|                                  |             |
|----------------------------------|-------------|
| United States appropriation----- | \$30,000.00 |
| Territorial and other funds----- | 18,041.46   |
| Total-----                       | 48,041.46   |

The organization of the marketing division met with more hearty popular support than any work heretofore done by the station. The organization of the official system of marketing led to a greatly increased production of poultry, pigs, and miscellaneous farm crops which are necessary to make Hawaii self-supporting from a food standpoint.

#### IDAHO.

**Agricultural Experiment Station of the University of Idaho, Moscow.**

W. L. CARLYLE, M. S., *Director.*

Encouraging progress was made in nearly all lines of investigation in which the station is interested. The live-stock equipment is particularly excellent. Although all of the stock belongs to the college, animals are available to the station for experimental purposes whenever the need arises. The State legislature provided for the establishment and maintenance of a poultry department and for field work in animal husbandry and dairying. Arrangements were made to carry on animal-husbandry work in cooperation with this department.

*Adams fund projects.*—On the station project on the bacteriology of soils attention was chiefly given to the influence of irrigation on bacterial activity, particularly on nitrification. The evidence thus far accumulated indicates that the nitrifying organisms are not washed from the soil to any appreciable extent. Four species of nitrifying organisms have been isolated and laboratory studies are in progress on the optimum temperature and moisture content for the growth and activity of these species.

The investigation of the influence of the degree of acidity of cream and of the amount of salt used upon the keeping quality and flavor of butter was completed and a preliminary account was prepared for publication. Possibly some of the experiments connected with this work will have to be repeated in cooperation with an organic chemist.

In connection with the work on apple breeding, about 6,000 seedlings, representing crosses of 8 standard varieties of apples, have been secured and are under observation. A large number of cross-pollinations was made during the year with the idea of introducing the seedlings thus obtained into the experiment. It is expected that some of the older trees will come into bearing within a year or two at which time the fruit characters may be studied. The investigation of an undetermined apple-tree disease was continued. An

organism was isolated from diseased portions of trees, but failed to induce the disease when inoculated into healthy trees. Later a bacterial organism somewhat resembling that of pear blight was isolated and further observations are being made to identify it and determine its connection with the disease.

Important data were accumulated in the investigation of the gluten content of wheat. It was found that a high content of nitrates in soil was at least coincident with the elaboration of the high percentage of protein in the grain. Turkey Red wheat and two varieties from Minnesota are being studied at Moscow and at each of the substations, with and without irrigation, for the purpose of determining the factors which contribute to differences in gluten content. Further work was done on the investigation of water requirements of plants, a study of colloids in Idaho soils, and on the effect of elevation and climate upon the amount of water required to produce a unit of dry matter in crops.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds, the animal husbandry department completed some experiments in feeding lambs and pigs. The results of feeding tests with lambs indicated that alfalfa hay can not be fed alone to lambs with profit. A grain mixture must be added. The superiority of legumes over common mixed hays in combination with grains was clearly demonstrated. When alfalfa hay was fed in suitable rations to lambs it appeared that the lambs could utilize this hay so as to give it a farm value of from \$9 to \$15 per ton. Wheat combined with oats gave more rapid and economic gains than barley as a feed for lambs. The experiments indicated that cutting or grinding of alfalfa hay as a lamb feed is not warranted by the results obtained.

In the pig-feeding experiments the value of tankage was clearly demonstrated. Other experiments were carried on to determine the economy of feeding small grains to calves, goats, and mature horses.

A rather extensive practical test is being made of the possibility of economic home canning. About 6,000 cans of fruits and vegetables were put up during the year, and in this work a careful record was kept of every item of expense. Practical experiments were also carried on with lime-sulphur spray for the control of apple scab, and with a variety of insecticides for the control of oyster-shell scale.

In tests with potatoes results were obtained which indicated the desirability of planting larger areas of potatoes in northern Idaho. It appeared that the soil should be prepared with unusual care and that best results were to be expected from Rural New Yorker, Gold Coin, and Netted Gem varieties.

In a series of irrigation experiments at the Gooding substation it was found that for the production of alfalfa hay seven or eight irri-

gations should be given during a three-crop season, totaling  $2\frac{3}{4}$  feet per acre; that for the production of wheat one or two applications of water, amounting to somewhat less than 1 foot per acre, should be given; and that for potato production about four irrigations should be given during the five or six weeks following the time when tubers begin to form, totaling about  $1\frac{3}{4}$  feet per acre.

The following publications were received from this station during the year: Bulletins 77, Lamb Feeding and Sheep Husbandry in Idaho; 78, Irrigation Practice—A Report of Four Years' Investigation at the Gooding Substation; and 79, Potato Culture for Northern Idaho—Potato Culture Under Irrigation—Dry Land Potato Culture—Potato Diseases and Insect Pests.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----           | \$15,000.00 |
| United States appropriation, Adams Act-----           | 15,000.00   |
| Farm products, including balance from previous year-- | 14,134.42   |
| Total-----  | 44,134.42   |

Through the operation of its substations the Idaho station is coming into more intimate touch with the agricultural problems and farmers of the State, and while thus gaining information of practical value to the members of the staff is making its influence more decidedly felt in the development of agricultural industries.

#### ILLINOIS.

Agricultural Experiment Station of the University of Illinois, *Urbana*.

EUGENE DAVENPORT, M. Agr., LL. D., *Director*.

The principal investigations carried on during the year were in animal breeding and nutrition, breeding of corn and of apples, spraying experiments on apple trees, soil fertility survey work, city milk supply, and culture of carnations. On account of the encroachment of the university campus upon the grounds of the experiment station, the experimental fields were established on new lands at some distance from the campus. A new group of greenhouse buildings for floriculture and vegetable growing was constructed at a cost of \$87,000. (Pl. I, fig. 1.) Four of the houses are to be used for research work. A new laboratory was equipped for the nutrition investigations, which are carried on under the Adams fund.

*Adams fund projects.*—Perhaps the most important body of scientific results achieved by the station's activities during the year was in the line of animal nutrition. Elaborate researches were made in the problem of the development of growing pigs. It was found

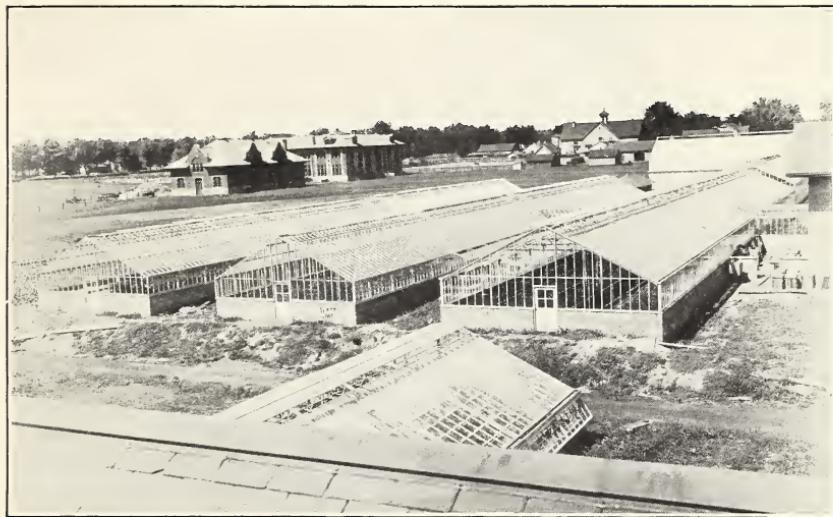


FIG. 1.—NEW FLORICULTURE AND VEGETABLE HOUSES, WITH COMPLETE EQUIPMENT,  
ILLINOIS STATION.



FIG. 2.—GENERAL VIEW OF SOME OF THE PLATS FOR FARM CROPS AND SOIL EXPERI-  
MENTS, IOWA STATION.



that a daily ration of corn, blood meal, and sufficient calcium phosphate containing only 0.32 pound of digestible protein per hundred pounds live weight was not sufficient for the normal nutrition of growing pigs. Similar rations, however, containing from 0.7 to 0.94 pound digestible protein proved sufficient for the normal nutrition of young pigs. There was no apparent difference in the effect upon the nutrition of growing pigs between rations furnishing 0.7 and those furnishing 0.94 pound digestible protein per hundred pounds live weight. Variations in the amount of digestible protein consumed did not influence significantly the percentages or distribution of ash in the bodies of growing pigs. About four-fifths of the ash was found in the skeleton, one-ninth in the meat, and about one-sixteenth in the offal, blood, and intestinal fats. The offal and carcases of younger animals were found to contain about twice as much ash as those of older pigs, while the skeleton contained only three-fourths as much ash.

Variations in the amount of digestible protein consumed by pigs proved not to influence greatly the percentages or distribution of inorganic phosphorus in the bodies of the pigs. In pigs 40 to 43 weeks old about four-fifths of the phosphorus was found in the skeleton, one-ninth in the meat, and one-hundredth in the offal. The investigation showed that from the eighteenth to the forty-third week of age the percentage of total phosphorus in the skeleton increased about one-half, while that in the entire body increased only about three-twentieths. Variations of from 0.32 to 0.94 pound digestible protein per 100 pounds live weight per day in the rations of growing pigs did not affect the nature of the nitrogenous material produced during the growth of the pigs. The results of this study indicated that, when the supply of food protein was deficient either quantitatively or qualitatively the only effect was upon the amount of body protein and not upon its character.

An elaborate study was made of the coefficients of digestibility of various common rations for swine. Evidence was obtained in this study that the coefficients of digestibility of the dry substances in rations composed of ground corn, ground corn and middlings, and ground corn and red dog flour were about equal. The same may be said for the coefficients of digestibility of crude protein, crude fat, and carbohydrates in these rations. It was found, however, that the coefficients of digestibility of one feed or ration may be increased or diminished by the addition of another feed or ration. There was in most cases a significant decrease in the coefficients of digestibility when the dry substance of a ration was reduced 26 per cent below the amount previously fed.

In a study of the digestibility of rations for steers it appeared that differences in the amounts of feed consumed influenced the

digestibility only when the quantity of crude fiber in a ration was relatively large. Otherwise none of the essential nutrients of the ration showed any change in the coefficients of digestibility as the result of changing the amount fed within reasonable limits.

An extensive statistical study was made of the published results of American feeding experiments with 5,127 lambs. In an analysis of these data it appeared that lambs weighing 50 to 70 pounds required 3.3 pounds of digestible protein daily to make satisfactory gains, that the protein requirement for lambs weighing 70 to 90 pounds is 2.8 pounds, and for lambs weighing 90 to 110 pounds the protein requirement was 2.2 to 2.4 pounds.

An application of statistical methods to a study of published results of feeding experiments for all kinds of domestic animals gave important data which may serve as a basis for caution in the interpretation of feeding experiments, particularly in the avoidance of unsafe conclusions from tests with too few animals without repetition of the experiment or without the exclusion of animals which depart too widely from the average. The analyses of the results indicated clearly that in any experiment involving two or more lots of animals the lots which exhibit the best average gains also exhibit the most uniform gains.

In an attempt to determine the independence or coupling of unit characters in mammals, work was conducted during the year for the most part with mice, wild gray mice being crossed with pink-eyed brown tame mice. More than 700 pedigreed individuals were raised for each of which a detailed record has been kept. Attention was directed particularly to the possible segregation or intensification of characters. This work will probably be extended to pigs during the coming year.

In the apple-breeding project an attempt was made to determine the relative value for purposes of propagation of large and small buds and of buds from different locations on the tree. This work has been carried on for a number of years, and a few of the oldest trees in the experiment flowered sparingly during the year. An extensive selection experiment was also in progress in which apple seedlings are grown from the best fruits from selected trees. The number of seedlings under observation during the year was about 2,500. Numerous reciprocal crosses were made between orchard varieties of apples and various species of the genus *Malus*. About 1,700 hybrid trees were kept under observation. This study also involves self-pollination of chosen individuals and the use on these same plants of pollen from trees of the same variety grown on different soils and under different conditions.

In a study of the injurious effects of spraying materials upon apple trees experiments were carried on involving tests of dry,

powdered, and paste arsenates of lead, lime-sulphur, and Bordeaux, copper ferrocyanid, and other insecticides and fungicides. These experiments showed that Bordeaux mixture applied under pressure of 160 to 225 pounds caused more russetting of the fruit than when applied at 125 pounds pressure. It was also found that large amounts of the spray caused more russetting than small amounts, indicating that varying the pressure and size of the nozzle openings was equivalent to varying the quantity of the spray.

In the project on inbreeding of animals few important results were brought to light during the year. Similarly the study of heredity in corn by the statistical method made only slight advance on account of the partial failure of the corn crop.

*Work with Hatch and other funds.*—With the support of Hatch and other funds a large amount of work was carried on as heretofore. The dairy department made decided progress in its elaborate study of city milk supply. This study is expected to furnish a basis for classifying city milk with regard to its commercial quality and also to furnish the foundation for grading dairies, determining the relative influence of various factors in the sanitary properties of milk and in arriving at some conclusion on the economics of dairying. On the point of the sanitary properties of milk the conclusion thus far reached is that under ordinary conditions the dairy utensils are the source of most of the bacteria which gain entrance to milk.

Corn breeding work undertaken for the purpose of changing the chemical composition of corn has been carried on at the station for 18 years. The extremes of protein content attained were 7.71 and 14.83 per cent. The extremes of oil content were 1.9 and 8.15 per cent. Considerable success was also obtained in fixing by selection a tendency for the ears to hang at a wide angle from the perpendicular and toward fixing the height at which the ears are borne on the stalk. It was also found that a number of abnormal characters may become hereditary to some extent. One strain of corn was found to throw albino plantlets to the extent of 25 per cent. In another strain barrenness of one-fourth of the seed appeared.

The soil-survey work was continued actively, about 4,000 square miles being covered during the year. This makes a total of nearly one-half of the State which has been covered by the soil survey. In this work it has been shown clearly that some soils are deficient in phosphates, others in potash, and that certain of the old agricultural soils have become slightly acid. Commercial fertilizers were found to be in every way as effective as barnyard manure in the production of a good quality of carnations. Acid phosphate seemed to be particularly adapted for use as fertilizer with this plant. Rotations of fertilizer plats were conducted on about 40 fields on different soils in various parts of the State.

Much experimental work in floriculture was carried on in the greenhouses, particularly on carnations, roses, and crysanthemums. Attention was also given to stem rot of carnations. Sweet potatoes were studied, particularly with reference to the fertilizer requirements and the possibilities of improving them by selection. In breeding work with lettuce the purpose was to secure a variety that would not be affected by tip burn. With this idea in view, crosses have been made with wild lettuce.

A definite attempt is being made to find, if possible, some organism which will grow on nonleguminous plants with the power of fixing atmospheric nitrogen. Tuberles were observed on *Ceanothus americana*. From these tubercles a strain of bacteria was obtained which was different from those on legumes. The sweet clover organisms have been inoculated into tomatoes, variously treated and stimulated, in order to determine whether this organism may be induced to grow on the tomato.

In animal industry an attempt is being made to work out the cost of producing beef on high-priced land with or without pasture, but with the use of silage. A careful record is being kept on all items of cost. Similar data are being accumulated from a study of sheep. For this purpose western ewes were purchased, and careful cost accounting is being kept on the maintenance of ewes and raising the lambs to market age.

The following publications were received from this station during the year: Bulletins 163, The Maintenance Requirement of Swine; 164, Milk Required to Raise a Dairy Calf; 165 (with abstract), The Element of Uncertainty in the Interpretation of Feeding Experiments; Circulars 165 (revised), Shall We Use "Complete" Commercial Fertilizers in the Corn Belt; 166, A Method for the Improvement of Buttermilk from Pasteurized Cream; 167 (also revision), The Illinois System of Permanent Fertility; 168 (also revision), Bread from Stones; 169, Economic Factors in Cattle Feeding, III; 170, The "Illinois Way" of Beautifying the Farm; 171, Late Broods of the Codling Moth; Soil Report 5, La Salle County Soils; 6, Knox County Soils; and the Annual Report for 1913.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----                        | \$15,000.00 |
| United States appropriation, Adams Act-----                        | 15,000.00   |
| State appropriation, including balance from previous<br>year ----- | 227,761.30  |
| Farm products, including balance from previous year-----           | 40,859.26   |
| Total -----  | 298,620.56  |

A large proportion of the work of the station is high-grade research and is yielding results of general interest, particularly in the

important field of animal nutrition. The station is also in close contact with the practical needs of the agriculture of the State and of the farming population.

#### INDIANA.

*Agricultural Experiment Station of Indiana, Lafayette.*

ARTHUR GOSS, M. S., A. C., *Director.*

The Indiana Legislature increased the mill-tax appropriation for Purdue University so that the total income of the university was about \$300,000 more than heretofore. The State authorities, however, construed this act as repealing all previous acts relating to the station. On account of the fact that certain standing appropriations thus lapsed the financial support of the station was no greater than had been the case. A bequest of two farms, one of 120 acres and the other of 360 acres, was made to the station by a resident of the State, and these farms will be used for work in horticulture, animal industry, and agronomy. New cattle-feeding sheds were erected about 210 feet in length and capable of accommodating 7 lots of 10 steers each. The work of the station was also extended by the stallion enrollment law, the hog-cholera act, and a creamery license act, the administration of which is placed under the station. New quarters for the station library were fitted up in the station building with a new set of cases and shelves.

*Adams fund projects.*—In the investigation of rusts, the behavior of various species under different climatic conditions in various parts of the Southwest was studied, and a large amount of new material was collected. A report on the rusts of grasses is being prepared for North American flora and will deal largely with the description, synonymy, hosts, and life history.

The plats used in the investigation of orchard management contain about 20 acres and work has been planned on a 15-year basis. The plats receive different treatment, such as clean tillage with cover crops for periods of 5 to 15 years and grass mulch with or without supplementary mulch. The records of the project include phenological notes, growth measures, meteorological data, soil temperature, analytical data on soil acidity and moisture, and bacteriological conditions.

The cream used in the study of pasteurization in relation to the bacterial flora and keeping quality of butter is that which is gathered for the university creamery. The butter is kept in storage and is scored every three months, and a chemical and bacteriological examination is made. The results thus-far obtained indicate that deterioration in butter can not be detected by chemical analysis. Part of the change is believed to be due to the oxidation of oleic acid. In the case of pasteurized cream there was less curd, and the curd was less

soluble. A temperature of 180° F. was the most efficient in destroying bacteria, but pasteurization efficiency was found to vary with the season on account of the variation in the bacterial flora of milk.

In the station's investigation of hog cholera, filtrates of hog-cholera blood and virulent normal salt solutions were largely used in the microscopic study of the virus. The use of an ultramicroscope showed no recognizable organisms. Serum from intravenous and intramuscular injections was compared, and variations in the virus at different periods of the disease were studied. It was noted that serum produced by the intravenous method did not show as satisfactory potency as when produced by the intramuscular method.

*Work with Hatch and other funds.*--The work carried on under Hatch and other funds involved a large range of experiments. An effective method of destroying wild garlic was developed, and spraying with orchard heating oil in the spring just before the heads begin to form was found to kill both above and below the soil. The application of oils was most effective when made on a warm day. Spraying with orchard heating oil and other substances was used with more or less success on other weeds. Progress was made on a plant disease survey, and a study was begun of the conditions which influence the cumulative action of injurious soil fungi.

A study of the tomato industry in Indiana showed that much of the seed now offered to growers is produced in Michigan, but that good seed can be grown in Indiana. The most highly productive varieties were Greater Baltimore, Favorite, and Royal Red. Plants grown in hotbeds produced about twice as much fruit as those started in the seed bed in the open ground.

Spraying experiments were continued to determine the relative efficiency of various preparations in the control of scab, brown rot, and curculio on peaches. The cover crops used in orchard work during the year included millet, buckwheat, rye, crimson clover, and cowpeas. Extensive variety tests were carried on with strawberries, currants, gooseberries, and other small fruits. On demonstration orchards in various parts of the State, data were accumulated on the economics of orcharding, on spraying, and other operations connected with orchard management. Information was also collected by experiments and observations for publication on the subject of vegetable gardening and the packing of apples.

The work of feed and fertilizer inspection continued to be very heavy. About 2,700 samples of feed were examined chemically and microscopically and 80 per cent were found to correspond with the guarantee. The chemical department also investigated the composition of corn at different stages of growth. It was found that all chemical ingredients increased until about October 1. After the formation of the ear began the dry matter, crude fiber, fat, nitrogen-

free extract, and starch in the stalks, blades, and husks remained practically constant, while they increased rapidly in the ear. The period of greatest starch formation occurred September 24 to October 1. When corn was supplied with water at regular intervals of irrigation, the plant took up about 35 per cent more nitrogen and more than twice as much potash as the crop is commonly stated to contain.

The entomological department continued its work on the codling moth, plum curculio, and Hessian fly. Some work was also begun on beekeeping with special reference to bee diseases.

In experiments in milk production it was found that in palatability a ration containing corn meal, wheat bran, and cottonseed meal stood first, while one containing ground corn and oats was rated third. The greatest economy of returns was obtained from the ration of ground corn and oats. Further experiments indicated that oats were nearly as good as bran for cows. The department of dairy husbandry also studied the influence of cottonseed meal on dairy heifers and the economy and efficiency of milking machines, and official tests of pure-bred stock were supervised by the department as well as the issuance of licenses for creamery testers. A large amount of data was also accumulated on the proper methods of sampling milk.

The department of animal husbandry continued its practical experiments in feeding the various classes of live stock. With steers the addition of corn silage to a ration of shelled corn, cottonseed meal, and clover hay decreased the grain consumption 2.38 pounds per day. The substitution of oat straw for clover hay produced no marked effect on the appetite, gains, or selling value of cattle. When soy-bean meal was substituted for cottonseed meal, the amount of feed consumed was reduced as well as the gains. In fattening western lambs, it was found that a grain ration of equal parts by weight of shelled corn and oats as compared with shelled corn alone did not affect the amount of feed consumed, but reduced the rate of gain about 8 per cent. Shorn lambs gained somewhat more rapidly than unshorn lambs, but the cost of gain was practically the same. Shearing had practically no effect on profit. Shelter for lambs did not give as good results as the open barn. Tankage used at the rate of 1 part to 8 to 10 of corn appeared to be the best supplement for corn in the ration for hogs.

In the poultry work of the station considerable attention was given to roup. Vaccines were prepared which, however, did not prove beneficial. Studies were continued on the cost of growing chicks. A new feature of the poultry work was the study of the cost of keeping ducks. Information was collected by statistical methods regarding the conditions of poultry production throughout the State.

For the use of the agronomy department there are six experimental farms available in various parts of the State to be used in soil and crop experiments. On these farms and at the main experiment station about 100 practical problems are being investigated. An investigation of certain unproductive soils of the Kankakee marsh region showed that these soils are well supplied with organic matter and nitrogen, fairly well furnished with phosphoric acid, but almost always deficient in potash. The soils were found to be excessively acid. The cause of the acidity is apparently aluminum nitrate. The rate of nitrification in these soils was found to be rapid, nitric acid combining with aluminum to form aluminum nitrate, which, in experiments, was demonstrated to be toxic to corn in very dilute solutions. The application of pulverized limestone or slaked lime at the rate of two to four tons per acre proved a very effective means of correcting this toxic condition, although the rate of nitrification was not thereby increased.

Experiments with soy beans and cowpeas demonstrated that these plants are well adapted to Indiana and capable of rapidly fixing nitrogen. Both of these legumes proved successful on soils that were too acid for clover production.

The following publications were received from this station during the year: Bulletins 165 (popular edition), Tomato Investigations; 166, Commercial Fertilizers; 167 (with popular edition), Winter Steer Feeding, 1912-13; 168, Fattening Western Lambs, 1912-13; 169, Commercial Feeding Stuffs; 170, The Reclamation of an Unproductive Soil of the Kankakee Marsh Region—Soil Acidity, Nitrification, and the Toxicity of Soluble Salts of Aluminum; 171, The Vegetable Garden; 172, Soy Beans and Cowpeas; 173, Hog Cholera; 174, Commercial Fertilizers; Circulars 29 (revised), Live Stock Judging for Beginners; 39, Packing Indiana Apples; 40, Report of Poultry Conditions in Indiana; 41, Licenses for Creameries and Testers—Laws, Rules, and Regulations; 42, Testing Milk and Cream for Butter Fat; 43, Stallion Enrollment, I; and the Annual Report for 1913.

The income of the station for the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act              | \$15,000.00 |
| United States appropriation, Adams Act              | 15,000.00   |
| State appropriation                                 | 91,000.00   |
| Miscellaneous, including balance from previous year | 194,363.20  |
| Total   | 315,363.20  |

The station has developed an excellent general equipment with the support of the generous appropriations from the State and has become an efficient agency for the advancement of agriculture.

## IOWA.

Iowa Agricultural Experiment Station, Ames.

C. F. CURTISS, M. S. A., D. Sc., *Director.*

The operations of the Iowa station were greatly extended during the year and the equipment was proportionately increased. The station came into possession of a 160-acre farm about 1 mile south of the dairy farm. This tract will be used for experimental work in agronomy, 40 acres for soil work, and the remainder for farm crops. Two barns were rebuilt and enlarged on this tract and an office and laboratory building were added to the equipment. During the year extensive improvements were also made on the dairy building. Work was begun on the new plant laboratory and greenhouses. In the cellar of the plant laboratory a cold-storage outfit will be installed with six refrigeration rooms for the use of the station and college. The chemical section was provided with more commodious quarters in the new chemical building. Mr. H. B. Munger was appointed chief in farm management.

*Adams fund projects.*—In the investigation of heredity in apples, quite definite correlations were established between structure and hardiness in different varieties. About 100 seedlings bore fruit last year and the seeds of this second generation were planted in the continuation of the project. A study is being made of the seeds of apples in relation to varieties as unit characters.

Trouble was experienced during the year in getting a good stand of leguminous plants in the orchard where the relation of humus and the physiological activities of the apple is being studied. A large number of careful measurements were made of the trunk of the trees, and the number, size, and weight of apples were recorded as measures of the influence of the different treatments. Attention was also given to the study of the leaf area and twig growth. The effect of the treatments with and without cover crops or mulch has not been uniform in so far as the size of the apples is concerned.

The soils department cooperated actively in the apple project and continued work on the general investigation of humus. It was found that previous results in a study of the nature of humus were somewhat unsatisfactory on account of the changes brought about in the nitrogenous compounds by the methods of extraction. A method was devised for the determination of amino acids and polypeptides in soils. A set of experiments was begun to determine the effects of applying ordinary humus-forming materials in varying amounts. The plats which had been receiving humus-forming material from various sources for six years without cropping are now available for bacteriological examination.

The application of barnyard manure up to 16 tons per acre increased the number of organisms in the soil and also the nitrifying power. The application of 20 tons of manure per acre, however, caused a depression in both the ammonifying and nitrifying power of the soil. The results obtained in bacteriological examination and the measurement of crop yields coincided very closely. The various amino acids and acid amids which were examined were found to readily undergo ammonification in the soil. Apparently amino acids and acid amids of equal structure yielded about the same proportion of ammonia.

In a study of methods for bacteriological examination of soils, albumin agar of the same composition as modified synthetic agar except that peptone was replaced by 0.1 gram of albumin per liter, permitted the development of larger numbers of bacteria than any other medium except an artificial humus agar. In connection with the study of humus the rôle of sulphur in relation to bacteria is being investigated.

The study of the so-called blue-gray hybrid cattle, produced by crossing white Shorthorns and Galloway cattle, has advanced to such a point that it will probably be terminated during the coming year. Preliminary conclusions have also been reached in the study of native Arkansas cows with reference to the influence of feed and environment on their offspring. In addition to the original records of the effects of environment and the inheritance of these effects a few digestion experiments were carried on with the cows and will be included in the bulletin soon to be prepared as a result of this series of experiments.

*Work with Hatch and other funds.*—Under the support of Hatch and State funds the work of the station has assumed a wide range. A truck-crop survey of the State is being carried on, and extensive cultural experiments and variety tests were made with potatoes, corn, cabbage, and melons. A series of practical tests were also carried out in orchard spraying, heating for frost protection, and for acquiring reliable data as a basis for general orchard management. A study of cold storage for Iowa apples proved that there was practically no difference in the results with the different kinds of packages, that the decay was slightly greater in apples obtained from the sod orchard, and that the large apples were the first to show the bad effects of cold storage.

A number of experimental tests were made of fence posts and methods of treatment for preservation. These tests, which have been continued for six or eight years, have yielded practical results to be put into bulletin form during the coming year. Special studies were made on white pine, cottonwood, and the European larch for

general planting in the State. Data were also accumulated and published on the wood-using industries of Iowa.

The work in agronomy included general studies with farm crops, breeding and variety tests with small grains and corn, soil surveys, soil-fertility studies, farm management, and supervision of the State experiment fields. The survey of plant food in various types of Iowa soils was practically completed during the year, over 400 soil samples being studied for the elements of plant food, as well as for acidity.

From tests of about 10,000 winter-wheat selections during the past seven years 120 pure lines were chosen for a field test, of which 72 will be used in the production of seed for distribution. Along the line of farm management, data were accumulated on Iowa farm tenantry, and a survey was made of 114 tenant farms to determine the amount and division of farm income. Elaborate plans were devised for future work in farm management.

The chief work of the dairy department during the year embraced the study of blue milk, the specific heat of milk, creamery organization, and a frozen dairy product called lacto, as well as the pasteurization of milk in bottles. The occurrence of blue milk studied at the station proved to be due to *Bacillus cyanogenes* in all cases. Careful determinations were made of the specific heat of whey, skim milk, whole milk, cream of various percentages, butter, and butter fat at different temperatures.

From a general study of the dairying conditions in the State much information was obtained as a basis for recommendations regarding the conditions under which cooperative creameries should be organized and operated. This information was published in bulletin form, with specific suggestions as to creamery equipment. It was found possible to prepare a frozen dairy product containing milk soured by specially prepared cultures, to which sugar, eggs, and a fruit extract were added. Further studies were made on pasteurization of sour cream, ice-cream manufacture, and on market milk.

In the department of agricultural engineering good results were obtained from the use of sewage for irrigation of barley, beets, and grasses, but with alfalfa the results were unfavorable. Attention was also given to devising plans for movable hog houses and for testing fence posts of wood, steel, and concrete. Plans for the construction of various kinds of silos were carefully worked out and published.

Along the line of animal industry much important work was accomplished during the year. A breeding experiment was begun in crossing Hampshire and Duroc-Jersey pigs. Color and other character segregations will be made. A number of breeding tests were also

instituted with poultry, and studies were carried on to determine the records of individual hens for egg production, weight of eggs, fertility, and on the cost of egg and fowl production.

The practice of hogging-down corn was given a thorough study. It was found that about 200 farmers have followed this practice for six years or more, and trials showed it to be an economical method of harvesting. Pork was produced more rapidly and cheaply than when corn was fed in the ordinary manner and no waste was experienced. In the practice of hogging corn it was found best to use small fields. Most farmers obtained the best results when the fields were not over 19 acres in size.

The botanical department continued a study of clover pollination. Little evidence of close pollination was obtained. The study has been extended to include various species of Leguminosæ. Work was also begun on the study of honey plants for the State and observations on Iowa weeds were continued.

In entomological work one of the most important lines was the study of codling moth under local conditions. Attention was also given to box elder aphid, strawberry slugs, cutworms, white grubs, and miscellaneous insects of orchard, garden, and field crops. Among the investigations of the chemical department, the most important was perhaps the study of lactic acid in corn silage and the study of lime-sulphur mixture containing lead arsenate. It was found that lactic acid is normally present in silage in excess of the volatile acids, the average ratio being 1 to 0.75. The form in which lactic acid occurs in silage proved to be optically inactive. As a result of mixing lead arsenate with lime-sulphur preparations it was found that the sulphur and calcium in the solution decreased, that the thiosulphate and sulphite increased, and that lead sulphid was formed.

The following publications were received from this station during the year: Bulletins 139, Creamery Organization and Construction, I and II; 140, Lacto—A Frczen Dairy Product; 141, Silo Construction; 142, Wood-working Industries of Iowa—The Timber Resources of Iowa—White Pine in Iowa; 143, Hogging-down Corn—A Successful Practice; 144, Cold Storage for Iowa Grown Apples; Research Bulletins 9, Amino Acids and Acid Amids as Sources of Ammonia in Soils; 10, Lactic Acid in Corn Silage; 11, Methods of the Bacteriological Examination of Soils; 12, Chemical Studies of the Lime-sulphur—Lead Arsenate Spray Mixture; Circulars 1, Home-made Seed Corn Testers; 2, Liming Iowa Soils; 3, Growing Alfalfa in Iowa; 4, Good Seed Corn for 1913; 5, Unlawful Iowa Weeds and Their Extermination; 6, Feeding Corn Silage to Farm Animals; 7, Bacteria in Relation to Soil Fertility; 8, Inoculation of Legumes; 9, Farm Manures; 10, Green Manuring and Soil Fertility; 11, Smut in

Small Grains with Treatments for Its Eradication; 12, Soiling Crops to Supplement Iowa Pastures; 13, Potatoes; 14, Some Common Internal Parasites (Worms) of Hogs and Their Treatment; 15, Testing Soils in the Laboratory and Field; 16, Care, Feed, and Management of the Dairy Herd; and 17, Rearing Chicks Successfully.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act----- | \$15,000.00 |
| United States appropriation, Adams Act----- | 15,000.00   |
| State appropriation-----                    | 99,200.00   |
| Farm products-----                          | 14,985.97   |
| Miscellaneous-----                          | 42.04       |
| Balance from previous year-----             | 17,858.25   |
| Total-----                                  | 162,086.26  |

The year was an unusually successful one for the Iowa station. The results from both investigational and practical work were of unusual importance, the staff came into closer touch with the agricultural problems in the State than ever before, and the financial and moral support of the institution was satisfactory in every way.

#### KANSAS.

##### Kansas Agricultural Experiment Station, Manhattan.

W. M. JARDINE, B. S. A., *Director.*

The scientific and administrative affairs of the station were systematized during the year by the adoption of better methods of organization. The slight changes which occurred in the staff and activities of the station were such as to make it possible to meet more adequately the demands of farmers and of scientific agriculture. A sanitary plant for the preparation of hog-cholera serum and a thoroughly equipped horse and cattle barn (Pl. II) to be used in part for experimental purposes were erected and special buildings for nutrition experiments with cattle and hogs were provided during the year. A dairy farm was established at the Fort Hays branch experiment station for the study of the economics of dairying and the relation of dairying to general farming. Probably the most complete experimental flour mill in the country was erected, at a cost of \$10,000. In this mill conveniences were furnished for testing all of the physical and chemical properties of flour. The laboratories in connection with the mill furnished facilities for baking tests. The whole equipment, therefore, gives conveniences for the scientific study of wheat from the grain to the loaf. An important addition to the equipment of the station was an apparatus for temperature and moisture control required in entomological and zoological investigations.

*Adams fund projects*.—Breeding experiments were continued in an endeavor to produce in wheat the hardy characteristics of spelt and emmer. Twenty-three families of hybrids were under study. The third generation showed parental characters of wheat, emmer, and spelt in pure form, and also the wheat characters combined with certain of those of spelt or emmer. The study was carried on by the head-to-row method, and the more promising of the strains obtained will be tested out on larger plats. Attention was given to the behavior of natural and artificial crosses as well as to the effect of varying degrees of temperature and moisture on pollination.

In alfalfa breeding 35 pure lines were under observation. An attempt is being made to study the inheritance in drought-resistant species and varieties of alfalfa and of crosses of alfalfa with other species of the same genus. Especial effort was being made to determine quantitatively the moisture requirements of different strains.

The study of climate as affecting injurious insects was carried on most actively with reference to the Hessian fly. A statistical study of the chief outbreaks of the Hessian fly in Kansas during the past 41 years, together with observations made during the year under report, showed that temperature and moisture are the only climatic elements that appear materially to influence the insect. Low temperature or low moisture or both acting simultaneously always retard the development of the Hessian fly, while high temperature and high moisture are favorable to its development. It is shown that predacious and parasitic enemies of the Hessian fly can not be depended upon for its control.

The investigation of insect pests of mills and stored grain yielded rather clear and definite results. The only practical and efficient method developed in these studies is the application of heat. This method was applied to several large mills with complete success, all insects being destroyed even in the inaccessible parts of the mill. All mill insects were destroyed by heating the mill to a temperature of 118° to 122° F. for 24 hours or more. No injury was thereby caused to any of the mill equipment or machinery.

The study of the molds which attack corn with reference to their possible connection with cerebritis in horses led largely to negative results. Some further investigation, however, will be made of the chemical properties of toxic emulsions prepared from moldy corn.

The effect of adding ash constituents and certain nitrogenous and nonnitrogenous constituents of milk, particularly serum, albumin, and casein, to a corn ration used in feeding pigs was strikingly interesting. Pigs fed corn meal without other feed were much below the normal development at the close of a six-months' period. The same was true for pigs fed corn meal and various ash ingredients. Pigs

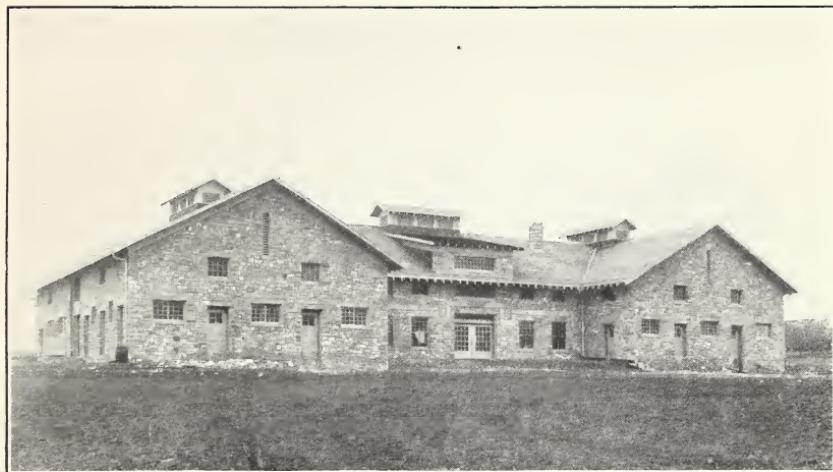


FIG. 1.—STONE HORSE AND CATTLE BARN, KANSAS COLLEGE AND STATION.

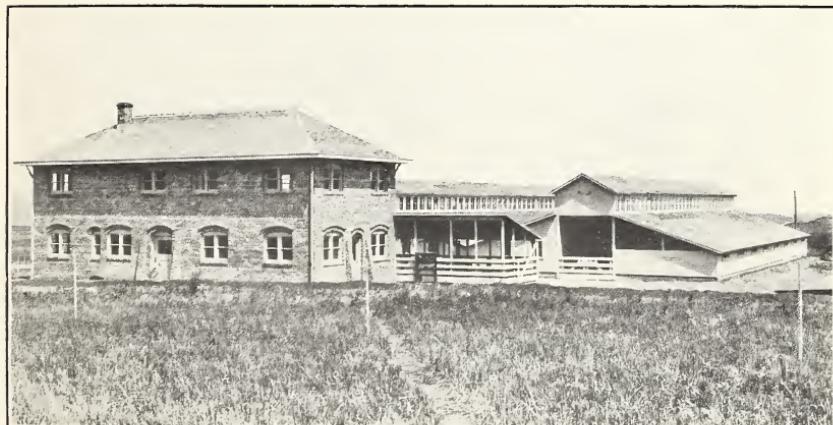


FIG. 2.—MODERN SANITARY PLANT FOR THE PRODUCTION OF HOG-CHOLERA SERUM,  
KANSAS STATION.



fed corn meal supplemented with practically ash-free proteins, however, developed normally. It was concluded that corn meal either does not furnish sufficient protein or lacks certain amino acids essential in animal growth. In a study of the effect of quantity of feed on body development in steers it appeared that liberal feeding from weaning to maturity allowed the maximum body development; that scanty feeding did not greatly check growth in height, but merely retarded the development of the middle and width of the body; and that one year of maintenance, if followed by liberal feeding, did not materially stunt the animal. In these experiments an elaborate system of body measurements was followed.

Investigations were continued on chick tapeworm and nematodes. An abundance of *Tenia serrata* became available, and upon this material a study was made of methods of producing evagination of the cysticerci. The cysticercus is ordinarily invaginated and requires attachment to the intestinal walls of the host for evagination. It was found possible to bring about the process of evagination by immersing the cysticerci in artificial pancreatic juices containing sodium carbonate and extract of pancreatin. Experiments in the transmission of *Heterakis perspicillum* showed that the earthworm *Helodrilus parvus* in some way serves as an intermediate host for this worm. The investigation of inheritance in Orthoptera was pursued with the genus *Paratettix*. It was shown that the characters of each parent are represented in the hybrids of the first generation. These grasshoppers did not exhibit characters which by crossing could be replaced by other different characters, but the whole color pattern appeared to be a unit character.

A continued study of the chinch-bug egg parasite showed that the egg parasite belongs to the species *Eumicrosoma benefica* and that the average percentage of parasitized chinch-bug eggs collected in various parts of the State was 16, the percentage ranging from 3 to 30.9.

*Work with Hatch and other funds.*—Many lines of work were carried on with the support of Hatch and other funds, including studies of soil fertility as related to the growth of wheat, corn, and alfalfa, tillage and moisture content of soils, improvement of corn, milling and baking tests of wheat, miscellaneous horticultural and entomological studies, and feeding experiments with farm animals. The results of the study of soil fertility showed commercial fertilizers in most instances to be unprofitable. Barnyard manure increased the yield of all crops, and phosphorus proved profitable on alfalfa.

The subject of seed-bed preparation was studied, with the result that the differences in yield of wheat on land plowed at different seasons appeared to be chiefly due to variations in the amount of nitrates

liberated rather than to other causes. Wheat on soil plowed July 15 gave an average yield of 28.58 bushels per acre, as compared with 24.94 bushels on land plowed August 15 and 13.62 bushels on ground plowed September 15. A few pure strains of wheat of decidedly superior yield have been developed and were distributed to the farmers for further testing on a large scale.

The influence of various substances upon the baking qualities of flour was studied. The substances used for this purpose were peptones, glycocoll, leucin, aspartic acid, asparagin, acetate, tartrate, chlorid, and phosphate of ammonium. The results showed that the baking qualities of flour are not determined by a definite relation between gliadin and glutenin, but bear an intimate relation to chemical substances that may naturally be present or may be introduced through imperfect milling. The most active substances were proteins.

The chinch bug was studied for the purpose of devising practical methods of control. No efficient natural enemies were found other than certain parasitic fungi. Additional evidence was obtained that the artificial distribution of parasitic fungi for this purpose is not financially justified. The cheapest method of destroying chinch bugs proved to be the use of fire in the winter quarters of the pest. A campaign was organized on a cooperative basis for the destruction of grasshoppers in western Kansas by the use of a poisoned bran mash. The campaign was successful in every way. It was estimated that 60 to 80 per cent of the grasshoppers were killed throughout the region where the method was applied.

From a statistical study of the yield of 226 varieties of corn tested since 1903 it appeared that no single variety is best under all conditions. High yields as a rule appeared to be a matter of variety, however, rather than color or maturing season. On the best farm lands of the State medium or late varieties produced the largest yields.

The survey of the alfalfa situation showed that in eastern Kansas the best results come from fall seeding, while spring seeding is preferable for western Kansas. Artificial inoculation of alfalfa was found unnecessary in central and western Kansas, but desirable in the eastern part of the State.

An elaborate set of experiments was made in the use of supplemental nitrogenous feeds in balancing corn as a ration for hogs. In these tests 364 hogs were used, and the supplemental feeds were tankage, meat meal, soy beans, shorts, alfalfa hay, and alfalfa meal. It was found that corn alone in the dry lot did not give satisfactory results, that hogs fed on pasture made cheaper gains than in the dry lot, and that economic returns were obtained from any of the rations in which supplemental feeds were used in addition to corn.

As a feed for work horses oats proved to be better, especially in hot weather, than corn. Barley was found to have practically the same feeding value as oats. Little difference in effectiveness was observed between bran and alfalfa meal, but old-process linseed meal was nearly four times as efficient as bran. Alfalfa hay showed itself to be a much more valuable roughage than either timothy or prairie hay, and reduced the cost of the ration.

The survey of the present distribution of apple blotch showed that this disease frequently causes over 90 per cent of injury to susceptible varieties. It was easily controlled by the application of Bordeaux mixture according to the 3:4:50 formula, and results indicated that the disease can be practically eradicated from an orchard by continuing this treatment for four or five years.

Among the other lines of work carried on during the year were methods of improving dairy herds, determining the feeding value of silage for dairy cows, selection of hens for egg yield, preparation and distribution of hog-cholera serum, the study of milk fever, and determination of the efficiency of pumping plants for irrigation.

The following publications were received from this station during the year: Bulletins 183, Kansas State Live Stock Registry Board, Report No. 3, October 1, 1912; 184, The Permit System of Cream Buying; 185, Preparing Land for Wheat; 186, Feeding Work Horses; 187, Analyses of Registered Fertilizers; 188, The Hessian Fly; 189, Methods of Controlling Mill and Stored-grain Insects, Together with the Habits and Life Histories of the Common Infesting Species; 190, The Baking Qualities of Flour as Influenced by Certain Chemical Substances, Milling By-products, and Germination of the Wheat; 191, The Chinch Bug; 192, Hog Feeding; 193, Variety Tests of Corn; 194, Potato Culture; 195, Analysis and Registration of Commerical Feedstuffs; 196, The Control of Apple Blotch; 197, Alfalfa in Kansas; Circulars 29, The Chinch Bug Situation in Kansas; 30, The Kansas Feeding Stuffs Law Revision of 1913; 31, Seed Corn for Kansas; 32, Burn the Chinch Bug in Winter Quarters; 33, The Chinese Arbor Vitæ (*Thuya orientalis*); 34, Sweet Clover; 35, Report of the Dickinson County Cow-testing Association; 36, Preparation of Exhibits for Fairs and Contests; and 37, The Hessian Fly Situation in Kansas.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act | \$15,000.00 |
| United States appropriation, Adams Act | 15,000.00   |
| State appropriation                    | 81,453.90   |
| Fees                                   | 16,449.12   |
| Total                                  | 127,903.02  |

With the improved administrative organization the operations of the working staff are directed more effectively than ever toward the solution of local agricultural problems and toward the building of scientific foundations for agriculture.

#### KENTUCKY.

##### Kentucky Agricultural Experiment Station, Lexington.

J. H. KASTLE, Ph. D., *Director.*

Notwithstanding the fact that the station still has to do a large amount of routine work, including bacteriological and chemical examination of water, analyses of soils, rocks, and minerals, and inspection work, the progress of organized research work is steadily increasing.

During the year a frame structure for the storage of grain, seeds, and other products of the experimental plats was erected. The cattle barn, capable of accommodating 75 to 100 animals, and also a cow shed were added to the equipment. An extensive poultry plant was built and well stocked with different types of chickens, and a new virus laboratory was erected. A new greenhouse for horticultural work was completed and the horticultural grounds were enlarged and improved. W. S. Anderson was appointed in charge of horse husbandry and D. D. Slade as superintendent of the poultry farm.

*Adams fund projects.*—Continued work on the Adams fund projects of the station led to many interesting results. An investigation of nodule bacteria was confined at first to alfalfa and sweet clover, but was later extended to various legumes. It was found in this work that even large-seeded plants like the garden pea and cowpea could be grown for a long time in test tubes so as to show the results of inoculation. Six different species of nodule bacteria were studied. It appeared that a species may produce nodules on only one plant or on several species, in which case the different species may not be all members of the same genus. The evidence indicated that an organism which does not naturally produce nodules on a certain plant can not be induced to adapt itself to this new host. The nodule organism of alfalfa and sweet clover was shown to be identical with that on *Medicago lupulina* and *M. denticulata*. All species of *Trifolium* were found to be affected by a single species of nodule organism, so that it does not matter from which species the culture is made for purposes of inoculating any of the clovers.

The life history of the corn-ear worm was fairly well worked out and attention was given to the injuries produced by it, its food plants, its distribution, and promising remedies for it. The corn-ear worm was found to pass the winter in the soil near the corn plants infested with the larvæ and to feed in the spring on early corn or tomatoes.

Late broods appeared often to be produced on tomatoes, late-planted corn, and other plants. The suggestions for control arising from this information, therefore, included winter plowing to break up the earth cells in which the larvae pupated and not allowing either early or late plantings of tomatoes or corn to be made in the vicinity of the regular corn fields.

From an investigation of infectious abortion of mares and jennets, it appeared that the organism which causes this disease can be differentiated from the ordinary *Bacillus abortus* and was therefore given the name *B. abortivus equinus*. Normal horse serum in tests at the station agglutinated the organism in a dilution of 1 to 200, while the serum of infected animals caused agglutination in a dilution of 1 to 500 to 1 to 5,000. Complement fixation was demonstrated in connection with the serum of the infected animals. Thus far only a partial immunity toward the disease has been produced. Further investigations confirm the fact that methylene blue is an effective remedy for contagious abortion in cows.

Much attention was given to the study of the solubility of the potash of soil silicates and to the effects of the salts of heavy metals in soils. A decided solvent action of yeasts on the potash of insoluble soil residues was demonstrated. The observed stimulating effect of barium and strontium on plant growth seemed to be catalytic in nature. The presence of relatively large amounts of manganese in the seed coat immediately surrounding the cotyledons of various plants was demonstrated, and the presence of manganese in that location is believed to indicate the possible functioning of manganese as an oxygen carrier in the germination of the seed. Pot experiments with manganese showed a marked benefit from the use of manganese carbonate on alfalfa. A simple and improved method for the determination of manganese in soils was devised. It was found in experiments with tobacco that this plant sometimes absorbs barium to an extent twice the maximum reported in loco weed. The content of barium sulphate in a great variety of plants was also determined.

Representative samples of soils from every geological area in the State were examined, from which it appeared that in most cases constant cultivation without manuring produces a loss in sulphur as compared with the corresponding virgin soil. The top soils generally contain more sulphur than their corresponding subsoils. It was concluded that any system of permanent soil fertility must consider the sulphur content of the soil.

A study of bloating of cows while feeding upon red or white clover or alfalfa at the time of flowering indicated that bloat may be due to the rapid fermentation in the stomach of the sugar naturally present in the blossoms of these plants. As much as 2.4 per cent by weight of sugar was found in the first blossoms of clover and alfalfa. It was

proved that fermentation of this sugar is readily produced by *Saccharomyces ellipsoideus II*. In the case of one cow, bloating was relieved within 20 minutes by the administration of a dilute solution of formaldehyde.

*Work with Hatch and other funds.*—A large amount of work, particularly in agronomy and animal husbandry, was carried on under the support of Hatch and other funds. This work included variety tests, breeding, and cultural methods with corn, small cereals, soy beans, forage, and soiling crops. Particular attention was given to the development of systems of crop rotation and soil improvement on experimental fields and farms in various parts of the State. A rather elaborate system of soil surveys was carried on.

Breeding experiments with tobacco included the improvement of native strains by pure-line breeding and seed selection and the effect of fertilizers and environment on yield and quality. An excellent strain of Jersey Fultz wheat has been developed at the station, and seed is being distributed to farmers for more extensive tests. The Burt type of oats was shown to be far superior to Kherson oats for Kentucky. It was found impossible to get satisfactory yields of alfalfa on the station ground without the use of lime. Lime proved to be absolutely essential to the successful growth of sweet clover.

The interesting fact was brought out from experiments that the yield of tobacco on the plat receiving no potash fertilizer for a series of years was practically the same as that obtained from a plat which received a liberal supply of potash.

In cooperation with this department, the inspection of seeds, nursery stock, and other importations was continued. Further work was also done on weeds and poisonous plants. The hymenopterous parasites of San José scale were investigated. Chemical analyses on an extensive scale were made of lime-sulphur solutions. A study was carried on of the ash of the sap, leaves, and young stems of the wild grape (*Vitis cordifolia*) with a view to throwing light on the mineral relationship of the sap to that of the growing tissues of the plant.

In feeding experiments with steers in the dry lot a better finish was obtained on a ration of ear corn, cottonseed meal, cottonseed hulls, and clover hay than upon the same ration with the addition of silage. A committee of experts rated the first lot of steers at 25 cents per hundredweight higher than the second lot. The ration for the second lot, however, was sufficiently cheaper to make the feeding of this lot more profitable. Another test of this question from a slightly different standpoint and with slightly varied conditions led to the same practical conclusions.

That corn is deficient as an exclusive ration for hogs was shown by the fact that pigs averaging 35 pounds at the beginning of an experi-

ment and fed corn meal alone in the dry lot gained but 25 pounds per head in 196 days, at a cost of 17.8 cents per pound, while the same pigs were made to gain 112 pounds per head in the next 155 days by supplementing the corn meal with shipstuff, green alfalfa, and alfalfa hay, at a cost of 5.3 cents per pound of gain. The average number of pounds of gain made per bushel of corn by the pigs which received the nitrogenous supplement to corn meal was 12.92 pounds. In this experiment pigs realized \$1.03 per bushel for grain which was valued at 69.7 cents per bushel.

A survey was made of the jack stock of Kentucky with reference to the suitability of different breeds for mule production. In a mule-feeding experiment no difficulty was experienced in gradually changing mules from their original ear-corn ration to a mixture containing bran, ear corn, and meal. Cottonseed meal was found not as palatable as linseed meal. Among the numerous other experiments which have been begun or have yielded preliminary results mention should be made of the study of the relation of the escutcheon of the dairy cow to milk and butter yield, the feeding value of ground wheat as compared with wheat bran, the inheritance of unit characters among horses, the construction and equipment of dairy barns, a study of the requirements of municipal abattoirs, an investigation of arthritis in colts, blackleg, malignant catarrhal fever, the thoroughbred horse, and miscellaneous veterinary and entomological work.

The publications received from this station during the year were as follows: Bulletins 168, Commercial Fertilizers; 172, Fumigation and Spraying; 173, The Municipal Abattoir; 174, The Sulphur Content of Some Typical Kentucky Soils; 175, The Growing and Fattening of Hogs in the Dry Lot and on Forage Crops; 176, Jack Stock of Kentucky—Rearing of Mules—Brood Mares for Producing Mules—Experiments in Feeding Mules; 178, Alfalfa and Sweet Clover; Food Inspection Regulation 8, Sanitary Regulation of the Killing, Handling, and Sale of Meat and Meat Products; Annual Report for 1911; Biennial Report 1912-13; Report Food and Drugs Act, 1910-11; and the Biennial Report of Food and Drug Control Work, 1911-1913.

The income of the station during the past fiscal year was as follows:

|   |                |
|---|----------------|
| United States appropriation, Hatch Act-----                     | \$15,000.00    |
| United States appropriation, Adams Act-----                     | 15,000.00      |
| State appropriation, including balance from previous year ----- | 28,632.09      |
| Fees, including balance from previous year-----                 | 67,550.69      |
| Farm products, including balance from previous year-----        | 14,133.96      |
| Miscellaneous, including balance from previous year-----        | 145,437.19     |
| <br>Total -----   | <br>285,753.93 |

Interest in the work of the station and demands upon it for assistance in various lines have been constantly growing. The research department, established under the immediate charge of the director, has led to the coordination of research work in all departments of the station and to an elevation of the standard of research.

#### LOUISIANA.

- No. 1. Sugar Experiment Station, *Audubon Park, New Orleans.*
- No. 2. State Experiment Station, *Baton Rouge.*
- No. 3. North Louisiana Experiment Station, *Calhoun.*
- No. 4. Rice Experiment Station, *Crowley.*

W. R. DODSON, A. B., B. S., *Director, Baton Rouge.*

It has been decided to transfer the irrigation experiment with rice, which has been in progress cooperatively for the past four years, to the Bureau of Plant Industry of this department. For this purpose 30 or more plats properly equipped with levees, irrigation, and drainage canals will be provided at the Rice substation. The land previously used for the irrigation experiments will be devoted to a four-year rotation of cotton, corn, soy beans, and cowpeas.

The force of the Bureau of Entomology cooperating with the station in the study of cane insects and other pests was increased. In this work particular attention was given to the cane borer. Dr. W. E. Cross resigned as chemist of the Sugar station. At the State station A. P. Kerr was made assistant director, I. Levin was added to the chemical force, and Dr. F. V. Emerson was assigned to work in soil surveys for one-half of his time.

*Adams fund projects.*—Satisfactory progress was made on most of the lines of work supported by Adams funds. The study of non-sugars of sugar cane was broadened to include clarification of cane juices, methods of analysis of cane products, and utilization of by-products of the manufacture of cane sugar. Experiments in the clarification of cane juice showed that liming the raw juice at a temperature of 60° C. caused a considerable darkening of the juice after clarification. The sulphured juice was found to contain a large amount of matter in suspension, which required precipitation and removal. A considerable increase in purity was thereby obtained, and the dried precipitate was demonstrated to be a source of cane wax. The question of the degree of acidity which may be considered safe under ordinary sugarhouse conditions was investigated, with the result that an appreciable inversion was noted with 3 cubic centimeters of acidity. An examination of the carbonation process indicated that this is too expensive a method to be employed in the manufacture of anything but the highest grade of plantation sugar.

The bacteriological study of raw sugars and sugarhouse products was prosecuted most actively along the line of culture media for the

quantitative estimation of microorganisms. The superior value demonstrated for the media of higher density was believed to be due to the injurious influence exercised upon some of the microorganisms by the change from the density of the film of moisture around sugar crystals to media of low density. The most favorable reaction for culture media was found to be neutrality with phenolphthalein as an indicator. The growth of microorganisms of sugars upon media of high density proved to be slower than upon those of low density. The matter of disinfectants was taken up in a thorough manner, since it was recognized that the deterioration of sugars is largely dependent upon the degree of infection during manufacture. In studying the cause of fermentation of cane sirup, the principal agency was found to be a species of yeast exceptionally resistant to high temperatures. Exposure to a temperature of 90° C. for 15 minutes was necessary to destroy this yeast.

In the investigation of anthrax perhaps the most noteworthy result was the demonstration that blood-sucking flies, particularly the horn fly, may be instrumental in transmitting the disease. If these flies engorge themselves shortly before the death of an animal suffering from anthrax, they may be able to transmit the disease by biting other animals. Vaccination of stock with attenuated cultures seemed to be effective. A study of the anthrax bacillus in soil, water, and decomposing carcasses showed that the organism persists for a long time in soil and water, but not long in the carcasses. Anthrax bacillus was not found in milk of living cows infected with the organism.

Experiments were carried on in feeding rabbits and hogs with cottonseed meal and cottonseed treated in various ways for the purpose of learning something definite about the toxicity of cottonseed products. It was found possible to feed sterilized meal in liberal amounts for 100 days without apparent injury. Boiling and fermenting the meal were less effective than sterilization. Considerable variation in the toxicity of cottonseed secured from different soils was noted.

A continuation of the study of stem rot of cane indicated that this disease is identical with the so-called Iliau disease of Hawaii. This disease is more prevalent in northern than in southern Louisiana. The relation of cane diseases to the germination of cane is receiving careful attention. Work on cotton wilt is confined chiefly to a continuation of selection for resistant strains. Some apparently immune strains were secured.

Various tomato diseases were studied, particularly tomato wilt. In the control of this disease a number of disinfectants were tried for treating the seed. The best results were obtained from soaking the seed 10 to 15 minutes in a solution of 1 part of corrosive sublimate

in 1,000 parts of water. Particularly resistant plants were noted in fields side by side with plants which were killed outright. Attention will be given to the selection of a resistant strain.

In the investigation of bean diseases it was found that anthracnose and blight are of greatest importance in Louisiana. The blight bacteria were shown to remain alive on seed beans from harvest until planting time. Experiments proved that these bacteria are very resistant to drying. Best results were obtained from saving seed from the spring crop, thoroughly drying them in the sun, fumigating to kill weevils, preserving in air-tight containers, and treating with a solution of corrosive sublimate before planting. Important data have been collected on methods of protecting rice against stored-grain insects, the insects which attack stored rice receiving attention with the idea of issuing a monograph on the subject.

Research was continued actively on the subject of heat transmission and entrainment in vacuum evaporating apparatus. It was demonstrated that the loss of heat in transmission due to hydrostatic head is less than would be expected from theoretical considerations. The lower the temperature level the smaller the coefficient of heat transmission was found to be. Air or other incondensable gases in the heating steam were found greatly to reduce heat transmission.

*Work with Hatch and other funds.*—A number of minor studies for the most part of a purely practical nature were carried on under the support of Hatch and other funds. Borax was found effective in destroying the house fly in manure, but the manure thus treated was found to be injurious when applied to crops. Calcium cyanamid was found to be more effective than other common forms of nitrogen as a fertilizer for cane, while calcium nitrate proved especially effective on corn. The economics of nitrogen fertilizers for cane is being studied. Much attention was given to the propagation of seedling varieties of cane, of which 1,027 have been tested in the field and analyzed for sugar content. Of this number 150 were retained as promising and 12 proved especially good. A cane harvester was tested with satisfactory results on the station farm.

The attempt to secure a weevil-proof flint corn by seed selection has shown promising progress.

Among the various forage crops tested at the station kudzu beans and Sudan grass proved to be of exceptional value. Variety tests were carried on with corn and cotton and systems of rotation experiments with these crops in the series are under investigation. At the Calhoun station numerous variety tests with corn, cotton, cowpeas, and velvet beans were carried on, together with tests of the effect of liming soils, inoculation of alfalfa, and various cultural investigations on corn, potatoes, sweet potatoes, grapes, tomatoes, apples,

cantaloups, and peaches. Twenty varieties of pecans were planted for further observation. Considerable attention was also devoted to vegetable culture as an industry, the use of silage feeding rations for live stock, and methods of suppressing the cottony cushion scale. A survey of the status of *Panicum hemitomum* indicated that this grass covers about 1,999,000 acres in the State and that it has an unusually high value as a hay and grazing grass.

At the Crowley Rice station rotation experiments included a series of plats, from which results were obtained showing a decided increase in yield wherever legumes had been used and also showing a decrease in the amount of red rice. Experiments with crude oil for controlling the rice weevil were fairly satisfactory. A study was begun to determine the relative value of nitrogen and phosphorus from different sources for rice.

The following publications were received from this station during the year: Bulletins 141, Vegetable Culture in North Louisiana; 142, Diseases of the Tomato in Louisiana; 143, Silos and Ensilage; 144, Clarification of Louisiana Cane Juices; 145, Suppression of the Cottony Cushion Scale in Louisiana; 148, Stock Feeding; Fertilizer Report, 1912-13; Feed Stuffs Report, 1912-13; and the Annual Reports for 1912 and 1913.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act----- | \$15,000.00 |
| United States appropriation, Adams Act----- | 15,000.00   |
| State appropriation -----                   | 22,000.00   |
| Fees -----                                  | 6,000.00    |
| Miscellaneous -----                         | 4,149.27    |
| Total-----                                  | 62,149.27   |

The scientific work of the station is becoming of more and more importance in the development of the chief industries of the State and the various practical studies at the different stations have brought the institution as a whole into intimate contact with the farmers.

#### MAINE.

Maine Agricultural Experiment Station, Orono.

C. D. Woods, Sc. D., Director.

The year was a very successful one for the Maine station. The increased activities of the station were accomplished economically and the efficiency of the scientific work was notable.

The work of the station was affected favorably by three acts of the State legislature, one relieving the director from the responsibility of enforcing laws regulating the sale of agricultural seeds, commercial feeding stuffs, fertilizers, drugs, etc.; a second providing an

appropriation of \$5,000 annually for investigations in animal husbandry; and a third providing a part of the money necessary for the purchase of a farm in Aroostook County. Private individuals assumed the financial responsibility for the rest of the expense connected with this farm. The farm contains 275 acres and will be used for experiments with oats, potatoes, and other crops.

Dr. F. M. Surface, of the Kentucky station, returned to the Maine station as biologist in charge of plant breeding. The plan of employing entomologists from other institutions for special work during the summer was adopted and put into operation.

*Adams fund projects.*—In the study of inheritance and other biological matters connected with the breeding of poultry a large amount of work was carried on which resulted in important scientific data. Crosses were made between Barred Plymouth Rocks and Black Hamburgs of the second generation, and also between bantams and Black Hamburgs. About 2,000 chicks were reared and weights taken at frequent intervals until they were 6 months old. Detailed data were secured on the heart weight, length and weight of the oviduct, and other intestinal organs in connection with the study of functions of reproduction and egg production. Crosses of Houdans with other breeds were made, and much histological work was done on inheritance of pigment in the legs of fowls. The evidence obtained indicated that in all probability a close correlation exists between the rate of growth of a pullet during the first six weeks after hatching and her subsequent performance as a layer.

Continued investigation of factors influencing the size, shape, and weight of the egg indicated that hens which lay large eggs usually lay eggs with a smaller proportion of yolk than hens which lay small eggs; that the eggs of an individual hen tend to be either uniform or variable in all of the egg characters; and that an individual hen is in general less variable in these respects than the race. It was found that the breadth of the egg is more closely correlated with the weight of the egg than its length, and that the weight of yolk, white, and shell is positively correlated with the weight of the other two parts of the egg. The weight of the egg and of the different egg parts, especially that of the yolk, increases as the bird matures. It appeared, as a general rule, that the first and last eggs of a litter are smaller than intermediate ones.

The study of the source of the white of the egg brought out some important information. It appeared that after entering the infundibulum the yolk remains in the so-called albumin portion of the oviduct about three hours. Before the acquisition of albumin by the egg is completed, it was demonstrated that a considerable amount of shell substance had already been deposited upon the shell membrane. The time required for the completion of the shell and the lay-

ing of the egg proved to range from 12 to 16 hours. In connection with the scientific study of poultry, much practical information was incidentally acquired regarding the feeding, care, and management of fowls.

By statistical methods in connection with herdbooks and other records an analysis was begun of the relation of age to performance in dairy cattle. In this work the data for 5,000 Holstein cows for four generations will be secured. The records of 17,000 Ayrshire cows of different ages will also be utilized. In investigating the normal variation of fat content of mixed milk it was shown that the greatest absolute mean fat production per day occurred in May, that the absolute amount of fat produced per day was about twice as variable as the percentage of fat in the milk, and that the absolute amount of fat was greatest in morning milk, while the percentage of fat in milk rose steadily from March to October.

A convenient mathematical scheme for the measurement of the degree of inbreeding was worked out on the assumption that the inbred individual possesses fewer different ancestors in any particular generation than the maximum possible number for that generation. The formula indicates the relation between the possible number and actual number of ancestors as a means of measuring the percentage of inbreeding.

In the oat-breeding experiments a change of plans was made whereby several small plats were used for each variety instead of a single large plat. The different plats of each variety were placed in widely separated parts of the field. Thirty-three of the most promising strains propagated from a single head selected in 1910 were grown on one-fortieth-acre plats. Some of these strains showed a yield of 5 to 10 bushels per acre more than the best of the standard varieties. A number of hybridizations have been made between different varieties of oats in an attempt to combine the best qualities of the two varieties.

The attempt to increase the vigor and yield of sweet corn by a system of crossing was continued. The results for the year were not satisfactory on account of unfavorable weather. The Cornforth corn was grown for the fourth year under careful selection and indicated marked improvement in earliness and vigor. Thus far the breeding and selection work with corn has shown that it was impossible to change the hereditary constitution of corn by the ear-to-row method of breeding, but that a certain amount of adjustment to local environment may be brought about. Extensive statistical records were collected on the growth of sweet corn which will form the basis of a future publication.

On account of the expensive and time-consuming features of breeding work with larger mammals, it is proposed for the coming year

to study some of the problems of heredity and animal physiology with small laboratory animals.

In the work of cross-breeding apples over 200 seedlings were obtained in addition to the same number of seedlings from self-pollinated fruit, and all were transplanted in the seedling nursery. The attempt to determine the mutual influence of stock and scion was continued in observations on 3,500 stocks which were budded in 1912 and are now under observation. An experiment was carried on with yellow-eye beans in which these plants were kept under fly screens, which excluded all insects. Most of the plants matured seed under these conditions, and further tests will be made to determine whether the type is breeding true.

Incidentally in connection with the breeding work a number of important determinations were made. It was found that the most accurate method for use in determining the bushel weight of grains consisted in settling the grain by shaking five times. This not only decreased the range of variability but slightly increased the grain weight of the bushel. It was found that in accordance with mathematical expectations a square plat offers a more accurate basis for the determination of varieties than any other rectangular plat of equal area. Tables were devised setting forth the ratios between a statistical deviation and a so-called probable error factor.

In the field of entomology, work was confined almost entirely to aphids. The important discovery was made that the elm is the primary host of the woolly aphis of the apple and that this insect passes the winter in the egg stage under the bark of the elm and migrates during the spring to the apple, upon which it lives until winter, when it migrates again to the elm. A greater protection of seedling apples from infestation may therefore be secured by establishing nurseries at a safe distance from susceptible elm trees or destroying elms in the vicinity of large nurseries.

The life histories of the various other species of woolly aphis which occur on the elm and of the aphids which are found on currant, gooseberry, and the members of the willow family, were carefully worked out and means of control determined as based on the life history of the pest. Notable additions were made to the food plant catalogue of the Aphidæ of the world.

The division of plant pathology continued the study of powdery scab of potatoes. The organism was determined as *Spongospora subterranea*. The symptoms of the disease were carefully studied for the purpose of differentiating between this and related diseases of the potato. The powdery scab was considered as the most serious disease with which the Maine potato growers had to contend.

In spraying experiments in connection with apple diseases it was shown that arsenate of lead has an appreciable fungicidal effect on

apple scab. As the experiments thus far conducted indicated, efficient scab control with a minimum of fruit russetting might be obtained by using lime-sulphur and Bordeaux mixture before the leaf buds open, with later applications of arsenate of lead. It was definitely determined that the European apple-tree canker caused by *Nectria ditissima* occurs in Maine. A study of pathogenic species of *Fusarium* disclosed the presence of 46 strains of this genus, all but 3 of which were isolated in the laboratory from diseased plants. A careful study of 32 of these strains indicated that they represent only 11 different species of *Fusarium*. At least two species were found associated with a decay of apples, and neither of these species was identical with any of the diseases causing apple rot in Europe.

*Work with Hatch and other funds.*—Practically no experimental work is carried on definitely under the Hatch fund. This fund is used mostly to supplement the research carried on under the Adams fund. With the support of the Hatch and other funds, however, a few studies were made incidental to the experimental work under the Adams fund. The top-dressing of meadows was found to be profitable if the hay crop was used for feeding on the farm. From a comparison of deep planting and medium planting of potatoes no decisive indication in favor of either method was obtained. Experiments with soy beans showed that this crop thrives in Maine wherever corn thrives, and that 8 tons of soy-bean fodder carried about the same amount of protein as 12 tons of corn. Spraying potato fields with iron sulphate resulted in the destruction of wild mustard and an immediate injury to the potato tops resembling the effects of frost, but the yield of tubers was apparently increased by this treatment.

The publications received from this station during the year were as follows: Bulletins 213, Aphid Pests of Maine, II; 214, The Biology of Poultry Keeping; 215, The Measurement of the Intensity of Inbreeding; 216, Poultry Notes, 1911-1913; 217, Woolly Aphid of the Apple; 218, Tables for Calculating Coefficients of Inbreeding; 219, Comparative Studies of Certain Disease-Producing Species of *Fusarium*; 220, Woolly Aphids of the Elm; 221, Constants for Normal Variation in the Fat Content of Mixed Milk—A Pedigree System for Use in Breeding Guinea Pigs and Rabbits—On the Ability of Chickens to Digest Small Pieces of Aluminum; 222, Finances, Meteorology, Index; 223, Spraying Experiments and Studies on Certain Apple Diseases in 1913; 224, Field Experiments; 225, Currant and Gooseberry Aphids in Maine; 226, Note on the Accuracy of Bushel Weight Determinations—Note on the Influence of Shape and Size of Plots in Tests of Varieties of Grain—A Table for Estimating the Probable Significance of Statistical Constants; 227, Powdery Scab of Potatoes; Official Inspections 48, Inspection of Drug Stores

and Analyses of Drugs; 49, Protection of Food Offered for Sale; 50, Feeding Stuff Inspection; 51, Weight of Butter; 52, Seed Inspection; 53, Fertilizer Inspection; 54, Insecticide and Fungicide Inspection; 55, Clams, Oysters, Scallops; 56, Carbonated and Other Beverages; and Document 480, Experiments at Highmoor Farm, 1913.

The income of the station for the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----           | \$15,000.00 |
| United States appropriation, Adams Act-----           | 15,000.00   |
| State appropriation, including balance from previous  |             |
| year -----  | 6,636.75    |
| Miscellaneous, including balance from previous year-- | 8,535.11    |
| Total -----   | 45,171.86   |

The Maine station is making decided contributions to the fundamental understanding of agricultural problems. Moreover, by means of its press leaflets and circulars it meets in a satisfactory way the practical demands of the farmers of the State.

#### MARYLAND.

*Maryland Agricultural Experiment Station, College Park.*

H. J. PATTERSON, B. S., *Director.*

The Maryland Legislature appropriated money for the purpose of purchasing a farm at Ridgely to be used as a substation. The farm contains 50 acres and is suitable for small fruits and general farming. A State appropriation of \$1,500 a year was made for maintaining the substation. The legislature failed to provide for the support of the biological laboratory for the manufacture of hog-cholera serum. An appropriation of \$10,000 was made for investigation of soil fertility in 1915 and \$20,000 for the year 1916. The poultry building which had been destroyed by fire was replaced by a brick building. Co-operative experiments with farmers in economic lines were conducted on 415 farms throughout the State.

*Adams fund projects.*—In continuing the investigation of the rapidity with which different forms of lime are diffused through the soil, a study was made of lime of different degrees of fineness and of combinations of lime in different kinds of soil. The project relating to the effect of sulphur and sulphur compounds upon cell structures involved the physiological study of the effect of chemicals applied through the roots of plants.

Interesting facts were brought to light in the study of the metabolic changes in potato tubers. It appeared that during the resting period of potatoes certain changes must occur in the chemical or physical condition of the buds or of their immediate surroundings

in order that growth may take place. The carbohydrate transformation during the rest period was shown to depend entirely upon changes of temperature. It was found that the juice from tubers at the end of the rest period possessed a greater oxidative power than juice from new immature tubers. Apparently the ripening process which occurs in potatoes during the rest period does not involve the hydrolysis of protein. No changes during this period were observed in the relative magnitudes of the various forms of nitrogenous bodies. When tubers were cut in half, it was found that the buds on the stem half nearest the exposed surface sprouted much sooner than was normally the case. The earliest sprouting occurred when the skins of potatoes were removed and tubers were cut in half transversely. It was also shown that the resting period of new potatoes may be shortened by wrapping the tubers in cotton saturated with hydrogen peroxid. It was concluded, therefore, that the elimination or abbreviation of the rest period is correlated with increased absorption of oxygen. In these experiments it was demonstrated that the rest period of potatoes was much reduced by the occurrence of the "little sprout" disease.

In the investigation of problems relating to city milk supplies serious objections from a sanitary standpoint were found to the use of all kinds of milk pails with a flat strainer. The use of glycerin or vaseline as a wash for the udder appeared to reduce the bacterial contamination of milk decidedly. Considerable attention was given to the study of curd as an index to the food value of milk, and an attempt was made to determine the cause of the well-known fact that infants are unable to digest and assimilate the fresh untreated milk of some cows. It was found that the size of the fat globules could not be considered an important factor in this problem of relative indigestibility of milk, since the size of the fat globules in human milk have the same range as in cow's milk. The popular belief in the relatively easy digestibility of the milk of Holstein and Ayrshire cows was found to be based upon scientific fact. The results obtained in connection with the reactions of milk proteids in the presence of precipitating solutions indicated clearly the flocculent nature of the curds from milk of these breeds and showed that the milk is not so easily curdled with the natural acid of the stomach as is the milk of the Jersey and Guernsey breeds. Some progress was made in developing a system of measuring cows to determine the proportions of different parts of the body and the possible correlation of these measurements with the productiveness of the cows.

*Work with Hatch and other funds.*—With the support of the Hatch fund, a wide variety of experiments was carried on. In the agronomy department crosses of two varieties of corn were studied

in ear-to-row tests and as first generation hybrids. Experiments with varieties, rate of planting, weight of seed, and other features of corn culture were conducted cooperatively with agricultural high schools and farmers throughout the State. A considerable amount of work was done in crossing wheat and oats and making single head selections from the more promising of about 60 varieties. Little encouragement was found in the improvement of cereals by continuous selection. A simple variety test, however, indicated that the general yield of wheat throughout the State could be increased by the use of the more productive varieties. Experiments were also carried on with Sudan grass, crimson clover, hairy vetch, cowpeas, and other legumes, and with fertilizers combined with green manure.

Seed inspection supported by State funds was carried on actively. During the year particular attention was given to a study of clover and vetch seed sold by various dealers in the State. In this work more than 1,100 samples were collected and examined, and tabulated results were published.

The horticultural work of the station included a great variety of experiments and observations. Crosses were made between the Kieffer and Seckel pear. Some of the 1,000 seedlings thus obtained have fruited and show marked variation in form, color, and flavor. Similar breeding work was carried on with apples. Crosses between Williams and Yellow Transparent proved promising. Breeding work was also conducted with grapes and strawberries. An experiment was begun to determine the suitability of crimson clover as a green manure crop for tomatoes. Miscellaneous experiments were also carried on with apple varieties; methods of planting, care of nursery stock, packing and shipping apples; varieties, culture, and disease of tomatoes; and varieties and culture of raspberries and other small fruits.

In cooperation with the State horticultural department and the Bureau of Plant Industry, breeding work was carried on to determine the possibility of wilt resistance in tomatoes and also spraying tests for the control of tomato blight. Experiments to determine the effect of solutions taken up by the roots of tomato plants upon the development of parasitic fungi attacking the plant gave negative results.

In addition to a number of miscellaneous entomological observations made during the year, particular attention was given to the habits and methods of control of woolly aphid, peach-tree borer, cut-worms, and of flies in dairy barns.

In continuing work with poultry a study was made of rations for chickens with a view to their simplification and in order to determine the effect of different feeds and rations on the hatchability of eggs. The egg records of a number of hens have been kept and breeding

experiments have been begun to learn the laws of inheritance of the color in eggs. In an attempt to originate a heavy, general-purpose breed laying white eggs, reciprocal crosses were made between White Leghorns and Plymouth Rocks. A beginning was also made in a poultry-disease survey of the State.

During the year surveys were made of the sheep and swine industries of the State to serve as a basis for future investigations. In this work data were collected on the present status of the industries, breeds, methods of breeding, and care and diseases of sheep and swine. Records were also obtained of the individual cows of a number of herds in connection with cow-testing associations in Maryland. This work has had an immediate effect in bringing about the elimination of unprofitable cows and the raising of milk records of different herds. The data obtained in this survey indicated that legume hays are not generally used by the dairymen in Maryland.

The following publications were received from this station during the year: Bulletins 176, The Peach-tree Borer; 177, Open Stables versus Closed Stables for Dairy Animals—A Comparison Between the Bacterial Content of Milk Drawn in the Closed Stable and in the Milking Room of the Open Stable; 178, Apple Orchard Experiments; 179, The Quality of Clover and Vetch Seed Found in Maryland Markets in 1913; and the Annual Report for 1912.

The income of the station during the past fiscal year was as follows:

|  |               |
|--|---------------|
| United States appropriation, Hatch Act-----              | \$15,000.00   |
| United States appropriation, Adams Act-----              | 15,000.00     |
| State appropriation-----                                 | 10,073.51     |
| Farm products, including balance from previous year----- | 9,115.35      |
| <br>Total-----   | <br>49,188.86 |

The work of the Maryland station has awakened the interest of the farmers throughout the State, and has enlisted the substantial support of the legislature for specific lines of investigation which seemed to be of most urgent importance.

#### MASSACHUSETTS.

Massachusetts Agricultural Experiment Station, Amherst.

W. P. BROOKS, Pd. D., Director.

No important changes in policy or lines of work occurred at the Massachusetts station during the year. The appropriation of the State legislature for the station was made on a basis of an annual increase of \$5,000 for the next four years. A mailing machine driven by electricity was installed for the use of the station. O. L. Clark was appointed vegetable physiologist and pathologist. The State

law enacted regarding printing makes it possible for the station bulletins to be printed as parts of the annual report and at State expense, thus relieving the station revenues for other purposes.

*Adams fund projects.*—The effect of five factors were studied in attempting to learn the cause of injuries from insecticides. Unusual opportunities were offered during the year for studying the influence of meteorological factors, particularly light, moisture, and temperature. More than 1,000 applications of insecticides were made in these studies on the trees of the college orchards. A large amount of material was collected for a study of the economic aspects of the digger wasps. These investigations pursued during the year were of an anatomical, systematic, and economical nature. In studying methods for the control of cranberry insects, an apparently important parasite was found of the cranberry fruit worm. This parasite was *Phanerotoma tibialis*. Its life history was carefully worked out.

Sanding experiments on dry cranberry bogs indicated that this method is not effective. The possibility of starving out fruit worms on dry bogs by killing the remnant of the bloom in seasons of severe injury from winterkilling was tested by spraying with a 20 per cent solution of iron sulphate. If further experiments prove that there is no danger from this method it looks feasible, judged by the results thus far obtained.

The investigation of the relation of climate to the development of plants in health and disease led to a considerable broadening of this line of study, which was later given more specific direction in two projects upon the relation of plant growth to light. In greenhouses morning light was shown to be from 10 to 30 per cent more effective than afternoon light. In order, therefore, to obtain the best results during winter it was recommended that greenhouses should stand about  $15^{\circ}$  to  $30^{\circ}$  north of east. No important differences were found in the light in greenhouses at different distances within 5 to 30 feet from the glass. A new electric method for determining light efficiency was perfected. By means of this instrument it is hoped that the effect of different intensities of light upon photosynthesis may be determined.

The results obtained in the study of chemistry of butter fat were of considerable importance. A method was perfected for determining the monohydroxy and dihydroxy acids and their glycerids. A modification of the Hehner and Mitchell method for determining stearic acids in the insoluble acids of butter fat was devised. An improvement was made on the method of determining the unsaponifiable matter of oils and fats by continuous extraction. Stearic acid was completely separated from the mixture of fatty acids and obtained in a pure crystalline form. Artificial butters were made up for testing the efficacy of these methods.

Work on the interrelation of stock and scion in apples made good progress. About 8,000 grafts were put out in the spring of 1914. An attempt is being made to root scions, and in this work some varieties present great difficulty; 14 varieties are being used on about 19 acres of land. A study was also made of the variations in apples caused by meteorological conditions. Ben Davis apples from the south quarters of trees were found to be constantly larger than those from other parts. Slight indications were noted of the relationships between size and average summer temperature, and a rather constant relationship was observed between the form of the apple and the temperature for a short period following bloom. The shorter this period the more elongated was the fruit.

Studies were also continued in the inheritance of pigmentation in garden beans, the inheritance of shape and color in squashes, and in the correlation between the weight of individual seeds of peas and the length of the vine. An investigation of the proper fertilizers and the best methods of applying them to asparagus showed that the asparagus growers are wasting fertilizers. Potash proved to be essential, but was beneficial only up to the rate of 300 pounds per acre, the muriate being superior to the sulphate of potash. Nitrate of soda was also highly beneficial but not economic at a rate exceeding 300 pounds per acre. Acid phosphate appeared to be relatively unimportant. Little correlation was found between the kind of fertilizer applied and the composition of the roots or between the roots and the amount of crop produced.

The study of fertilizers for cranberries did not bring forth many convincing results during the year. Nitrate of soda appeared to be the only really effective fertilizer but the results from some of the tests were perplexing. Work was begun in the analysis of the drainage water from the experimental cranberry bogs to determine whether and to what extent fertilizer materials are leached out.

The solubility effect of ammonium sulphate on the soil was investigated and some definite results were obtained. Analysis of the drainage waters showed an exhaustion of calcium as a base but no accumulation of free sulphuric acid. It was concluded that the chemical reaction which takes place is chiefly the formation of soluble sulphates of calcium first and later of aluminum and iron. Some evidence was obtained that a slow solution of silicic acid occurs. An analysis of various parts of the clover plants will be made to determine the effect of lime on the composition of this plant.

*Work with Hatch and other funds.*—A variety of studies and experiments were carried on under Hatch and other funds. Information was accumulated on the dates of hatching of scale insects as a foundation for spraying. The life history of the Marguerite fly was worked out, and insecticidal methods were tested on the onion

maggot. The distribution and habits of several other insect pests were studied, particularly the elm-leaf beetle and asparagus beetle. In a study of *Bacillus pullorum* as a cause of bacillary white diarrhea of chicks it was found that this organism may occur in the egg of infected fowls. The agglutination test proved a satisfactory method for the detection of diseased hens. Rabbits were found to react from injections of pure cultures of *B. pullorum*, yielding active bacteriolytic sera.

In miscellaneous work with apples and peaches considerable attention was given to cover crops and pruning and variety tests. The station rendered much help in testing cows for advanced registry, and also in determining the effectiveness of alfalfa for milk production. Careful records were kept of the items entering into the cost of milk production. It was found that the average yearly cost of keeping cows was \$145.24 per head, that the food cost of a quart of milk under station conditions was 3.33 cents, and the total cost 5.45 cents per quart. Studies were also continued on the individuality of hens with reference to the inheritance of egg-producing power. An attempt is being made to determine whether egg laying is chiefly constitutional or hereditary.

In the numerous fertilizer tests carried on at the station it was found that sulphate of potash was superior to muriate of potash for blackberries, raspberries, and alfalfa, and also had an apparent effect in keeping down the percentage of weeds. The weight of bearing wood in the case of raspberries was also in favor of sulphate of potash. Sulphate of ammonia proved to be the best form of nitrogen for strawberries and basic slag meal the best source of phosphate. In experiments with oats sulphate of ammonia proved to be the most efficient source of nitrogen.

The publications received from this station during the year were as follows: Bulletins 144, The Relation of Light to Greenhouse Culture; 145, Record of the Station Dairy Herd and the Cost of Milk Production; 146, Inspection of Commercial Feed Stuffs; 147, Inspection of Commercial Fertilizers; Meteorological Bulletins 294-305; Circular 35, Poultry Manures, Their Treatment and Use; and the Annual Report for 1912, parts 1 and 2.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act                    | \$15,000.00 |
| United States appropriation, Adams Act                    | 15,000.00   |
| State appropriation, including balance from previous year | 35,074.55   |
| Fees  | 11,244.00   |
| Farm products   | 9,061.91    |
| Miscellaneous   | 9,631.40    |
| Total   | 95,011.86   |

The station is actively carrying on investigations along a number of lines which are of great importance to the agriculture of the State. In this work its scientific investigations have shown a very fundamental character, and its numerous experiments have had a very practical bearing.

#### MICHIGAN.

*Experiment Station of Michigan State Agricultural College, East Lansing.*

R. S. SHAW, B. S. A., *Director.*

The station has felt the lack of adequate State funds to supplement the Federal appropriations and was somewhat handicapped during the year by the temporary suspension of the State funds for the college and station. The legal question at issue was finally settled by the courts in favor of the college, and the experiment station did not materially suffer from actual lack of funds. There were several changes in the staff during the year. M. M. McCool succeeded J. A. Jeffery as head of the soils department, H. J. Eustace was appointed to the position of vice director, and O. F. Jensen succeeded A. K. Hart as assistant in chemistry. A new dairy building was completed and occupied (Pl. III, fig. 1). This building is, however, largely for commercial and teaching work.

*Adams fund projects.*—The investigation of agents, which render available the insoluble elements of the soil, were subdivided into a number of more or less related lines of study, including the isolation of individual compounds and the study of the combinations in which nitrogen occurs and the relation of mineral matters to one another in the process of absorption by plants. Particular attention was given to a study of the variation of nitrogen in peat soils according to the age of the peat. This study was made in a vertical road cut which exposed a considerable depth of peat. From observations on peat and muck lands it appeared that a large portion of these lands could be used for permanent production of crops by draining and the use of suitable fertilizers, particularly potash and phosphoric acid. Portions of the peat may also be used in mixing with manure to produce compost. Much work was also done upon the soil solution, particularly on methods of obtaining samples of it in an unchanged condition. If this proves to be impracticable an attempt will be made to synthesize the soil solution and carry on experiments with this artificial medium. Another phase of this soil project was concerned with osmosis in soils with especial reference to the adsorption of different basic constituents in relation to acidity. It appeared that the reaction of acid soils of the sandy loam type was one of selective adsorption by the soil of the basic constituents of the neutral salt solution. Kaolin, in its natural condition, did not show the

power of selective adsorption. The acidity of these soils apparently arose from the formation of soluble salts in the interaction of weak acids.

Some progress was made on a study of the manner in which insecticides kill the insects. Particular attention was given to the vapors of kerosene and similar insecticides and their absorption by the blood of insects. A study of the twig and limb cankers of apple and peach led to a determination of the fungus which causes this disease. The organism was isolated and its pathogenic properties determined by inoculation.

The bacterial flora of butter was studied in connection with the investigation of the keeping qualities of butter with particular reference to the individual and associative action of the bacteria on the constituents of the butter. In this work the butter was held in cold storage and samples drawn from time to time. The investigations seemed to be nearing the point where the bacteriological cause of the chemical decomposition of butter will be definitely determined. Some attention was also given to antibodies in milk, and the effect of abortion in cows upon the properties of milk.

The study of epizootics of swine was continued, attention being devoted chiefly to a determination of the relation of *Bacillus cholerae suis* and other organisms to the filterable virus in causing hog cholera. Some evidence was obtained that forms of disease which have been known as hog cholera may be caused by organisms as well as by filterable virus. Considerable time was devoted to the methods of increasing the amount of virus by intraperitoneal injections of salt solution. Apparently this may lead not to a mere dilution of the virus, but to an actual increase in the amount of virus. In pursuing further the studies of infectious abortion of cattle, it was found that a local treatment with sour whey was decidedly effective in preventing the permanent sterility of cows after abortion. Further work was also done on the agglutination test, complement fixation, and treatment of guinea pigs with methylene blue, to ascertain the effect of this chemical upon the development of the bacillus of abortion.

*Work with Hatch and other funds.*—All of the departments of the station carried on work under Hatch and other funds. The horticultural work included a study of the effect of thinning apples and plums, top-working young apples of early bearing kinds, the use of various stocks for sour cherries, and breeding work with orchard fruits, potatoes, tomatoes, lettuce, sweet corn, gooseberries, and currants. The financial aspects of commercial peach growing in Michigan have been studied for a period of six years. A summary of the observations made during that period indicated that the average profit per acre from peaches was \$37.41, the average net profit per bushel being 74 cents, and the average cost of production per bushel



FIG. 1.—NEW DAIRY BUILDING, COMPLETED IN JANUARY, 1914, MICHIGAN STATION.

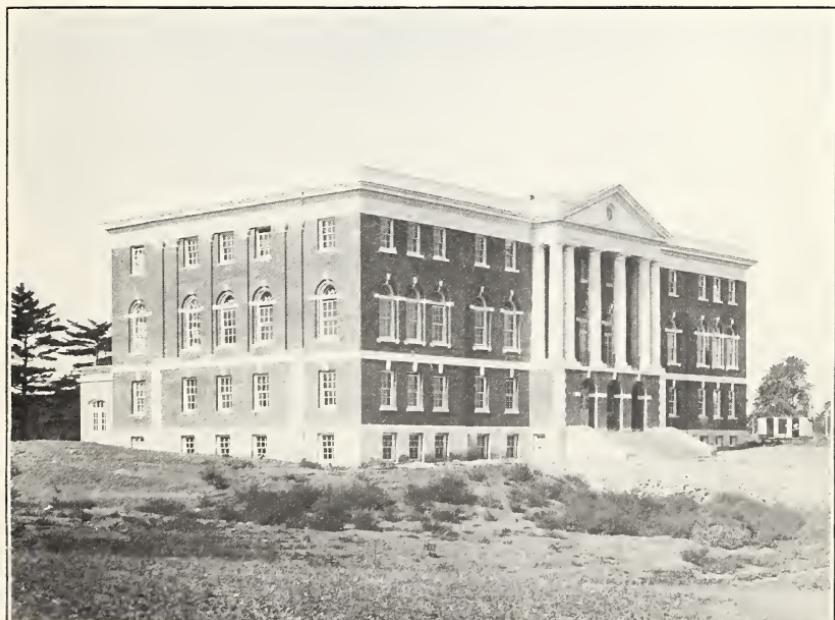


FIG. 2.—AGRICULTURAL BUILDING, COST \$100,000, EQUIPMENT \$20,000, NEW JERSEY COLLEGE AND STATION.



57 cents. Experiments were carried on to determine the probable cultural methods, fertilizers, and methods of handling onions on muck soils. A considerable number of spraying experiments were conducted, particularly with reference to the treatment of plums, cherries, grapes, small fruits, potatoes, tomatoes, and muskmelons for the common insect pests and fungus diseases to which they are susceptible.

In the field of agronomy, breeding and crop-improvement work was conducted with cereals, alfalfa, clovers, beans, soy beans, and cowpeas. The rotation and soil-fertility work inaugurated in 1911 was continued actively, and variety tests of corn were continued with reference to regional adaptation of varieties. Further testing by farmers of a winter barley originated at the station indicated that this variety is about as hardy as wheat.

In the chemical department considerable progress was made in developing a rapid method for the determination of lime in marls and limestone, and for the determination of calcium and strontium in the presence of each other. Some attention was given to the matter of deterioration of cement tile, concerning which numerous complaints have been received from various parts of the State. Apparently in the presence of large amounts of carbon dioxide in soil or in sewage which may be allowed to run through the tiles, the solubility of lime in the cement tile increases. In a study of soil acidity it was shown that the reaction with litmus paper is due to the absorptive power of soils, and that soil acidity is really an absence of lime rather than an actual presence of an acid.

Work was actively conducted on the carrot-rust fly and on parasites of San José scale. A number of species have been bred from this pest and some from the oyster-shell scale. Some attention was also given to the cotton worm, which frequently attacks peaches in Michigan. Notes were also collected on the occurrence of the army worm, tamarack sawfly, and other injurious insects. Inspection of bees with reference to foul brood has been placed in charge of the entomological department. Some practical methods for controlling foul brood have been worked out.

In the field of plant pathology attention was given to bean diseases, particularly blight and anthracnose. Work was also done on a new celery disease at Kalamazoo. This disease appears to be of bacterial origin. The only effective treatment thus far devised is the application of steam to the soil. From an extensive series of observations and practical experiments with potato diseases material was obtained for a bulletin reporting the practical results of these experiments and indicating the most efficient methods for controlling late blight, early blight, Rhizoctonia, dry rot, Fusarium wilt, and other potato diseases. The division of bacteriology was occupied with a number of investiga-

tions. A bacterial disease of white grubs was carefully studied. This disease was found to be due to a *Micrococcus*, which causes a rapid blackening and death of white grubs. The same organism appears to affect certain other closely related species. Practical experiments in distributing cultures of this organism in soils indicated that the *Micrococcus* may be useful in cooperation with other parasitic diseases in combating white grubs.

From a study of the hog-cholera situation in Michigan it was recognized that healthy herds should not be treated by the simultaneous method, but with serum alone, unless the herds were in immediate danger of infection with cholera. It was also strongly urged that the herd should be treated with serum as soon as the disease appears in the immediate vicinity, and without waiting for the appearance of the disease in the herd. Further work was conducted in perfecting the practical details connected with the tuberculin test of cattle.

The department of animal industry conducted some experiments in rearing calves on skim milk in which the milk was kept from souring by the use of formaldehyde as a preservative. The formaldehyde badly affected some of the calves. A test was also made of practical methods of wintering ewes, the best results being obtained with 2 pounds of silage and bean hay. Work was begun on a study of the cost of producing milk, milk records being taken on 25 milk farms. In a study of herds, particularly in connection with advanced registry, a much greater variation was found in the percentage of butter fat in milk than was generally supposed. In some cases the variation ran from 3.2 to 8.8 per cent of fat within 12 hours. In 55 out of the 200 cows under observation, however, 27.5 per cent of them showed a variation in butter fat of not over 1 per cent.

The following publications were received from this station during the year: Bulletin 272, Fertilizer Analyses; Technical Bulletin 17, An Investigation of Soil Temperature and Some of the Most Important Factors Influencing It; Special Bulletins 62, The Tuberculin Tests for Tuberculosis in Cattle; 63, Commercial Peach Growing in Michigan; 67, Onion Culture on Muck Lands; 68, Two Michigan Bean Diseases; 70, Michigan Agriculture—Its Present Status and Wonderful Possibilities; and the Annual Report for 1913.

The income of the station during the past fiscal year was as follows:

|   |               |
|---|---------------|
| United States appropriation, Hatch Act-----           | \$15,000.00   |
| United States appropriation, Adams Act-----           | 15,000.00     |
| State appropriation-----                              | 18,000.00     |
| Fees -----  | 6,280.00      |
| Miscellaneous, including balance from previous year-- | 6,112.90      |
| <br>Total -----                                       | <br>60,392.90 |

The work of the Michigan station as a whole is steadily improving in thoroughness and effectiveness. There is a need of somewhat larger State appropriations to supplement the work now carried on by Federal funds.

#### MINNESOTA.

Agricultural Experiment Station of the University of Minnesota, *University Farm, St. Paul.*

A. F. Woods, M. A., *Director.*

A reorganization of the divisions of the station according to a new plan resulted in a number of staff changes which made possible a closer adjustment of the work to requirements, a better division of labor, and, consequently, more effective operations. The old greenhouses were replaced by new structures of concrete and steel, and additional houses were erected for the divisions of agronomy, botany and plant pathology, entomology, and soils. A new poultry house (Pl. V, figs. 1 and 2) was added to the station equipment, alterations were completed in the horse barn, and an addition made to dairy hall. Much of the farm was refenced and numerous other improvements effected. At Crookston a grain storage and cleaning plant was built. As a whole, the year was marked by an unusual extent of investigations in the field of rural economics.

*Adams fund projects.*—In the Adams fund work of the station satisfactory progress was made in all projects except one in entomology, in which the requisite insect material, for some unforeseen reason, could not be obtained. In the investigations on the effect of feed upon beef and milk, the latter phase of the problem was practically completed. A tabulation of data accumulated in the feeding experiments with dairy cows since 1894 indicated that for the greater part of this period a daily protein supply of 2 pounds gave the largest yield of butter fat. The experimental results also indicated that 1.75 units of net crude protein should be allowed in the ration for one unit of protein in the milk.

The work on the effect of feed upon beef was carried on actively, and will constitute the main feature of the project for the coming year. The veterinary project on a study of the normal blood of the hog was completed, and a bulletin on the subject will be issued during the coming year.

Special emphasis is given to a study of inheritance in varieties of various fruits in the project on heredity and climatic resistance of apples, plums, and strawberries. It was found difficult to cross plum hybrids, and a study was therefore undertaken to determine the cause of the sterility. A careful study is being made of the pollen of these fruits under field conditions. It was found that the nuclei of mature pollen in both the plum and strawberry were abnormal

and degenerated. The behavior of several hundred crosses of strawberries toward winterkilling was studied with the result that a marked difference in different varieties was found under field conditions.

Systematic studies have been continued on the rusts of cereals. Direct transfers of *Puccinia graminis* were made from oats to wheat and rye. There appeared to be a physiological and even a slight morphological change in the rust fungus when grown continuously on a semi-immune host and the degree of incompatibility of host and parasite was found to vary greatly. Only two varieties of wheat, Khapli and Kubanka 2094, possessed any marked degree of resistance to inoculation with rust. The interesting fact was noted that the more resistant the variety the more pronounced the tendency of the rust to destroy only minute areas of the leaf and the greater the length of the incubation period. In general it was found that the absence or presence in excessive amounts of various plant foods in the soil did not directly affect the immunity or susceptibility of wheat.

Further information is being accumulated on the biology of *Bryocophagus funebris* and the wheat-stem maggot, with the prospect that complete accounts of these insects will be published during the coming year.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds a great variety of work was carried on. In the division of agronomy pure seed, especially of small grain and corn, was produced in large quantities and distributed to farmers for the purpose of improving their strains of these crops. Experimental results obtained during the year indicated that sugar-beet seed of high quality may be produced in Minnesota, with the result that this may become a new industry for the State. Good crops of tobacco were obtained at the station, and better success than heretofore was had in harvesting and marketing the product. Experiments were also made in comparing acclimated and imported oats for seed, in comparing small, medium, and large grains of wheat for seed purposes, in determining the stage of growth at which to cut corn for silage, and in gaining information on the best method of seeding alfalfa. Experience at the station indicated that inoculation is highly important in securing a good stand of alfalfa in Minnesota.

Crosses of winter and spring wheat yielded several good strains that give promise of being superior varieties. A number of minor plant-breeding projects were begun during the year, especially to determine the relation of show points to yield in corn, the effect of cross-breeding upon earliness of corn, the effect of temperature at which germination occurs, commercial fertilizers, and cultural

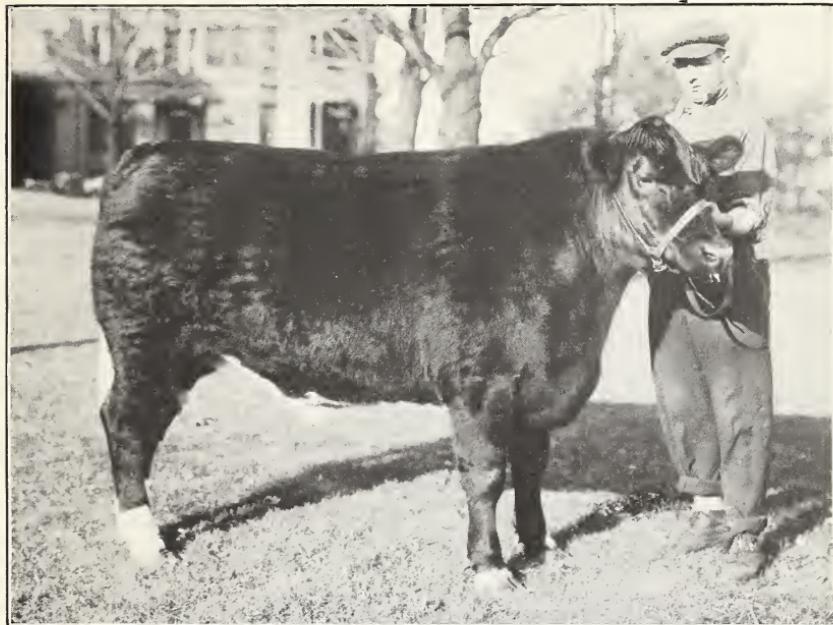


FIG. 1.—GRAND CHAMPION BEEF STEER, INTERNATIONAL LIVE STOCK EXPOSITION,  
DECEMBER, 1913, UNIVERSITY OF MINNESOTA.



FIG. 2.—JUNIOR YEARLING SHORTHORN, INTERNATIONAL LIVE STOCK EXPOSITION,  
DECEMBER, 1913, UNIVERSITY OF MINNESOTA.

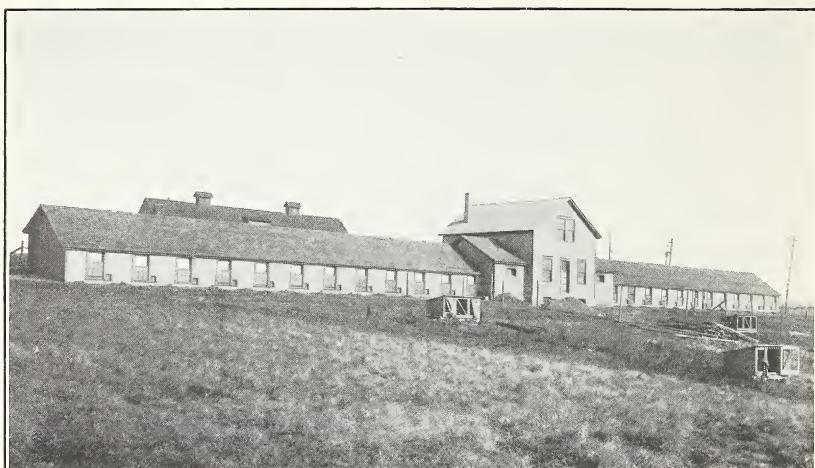


FIG. 1.—NEW BROODER HOUSE, PART OF THE POULTRY PLANT, MINNESOTA COLLEGE AND STATION.



FIG. 2.—NEW LAYING HOUSE, PART OF THE POULTRY PLANT, MINNESOTA COLLEGE AND STATION.

methods upon the earliness of corn, and the possibility of improving various small grains by hybridization.

In the study of the cost of producing farm products statistics were obtained during the year from 9 additional farms on diversified farming, from 11 farms on the cost of meat production, and from 6 market gardeners on the cost of producing garden products. Complete data were also brought together on farm equipment, representing a survey of 120 farms, and on the general farm management surveys from 650 farms in Rice County. This information has been prepared for publication.

The work of the division of research and agricultural economics was devoted chiefly to problems of marketing and cooperation. A preliminary survey of cooperation in the State indicated that there are 2,013 cooperative associations among farmers in Minnesota and that the volume of business carried on by these associations annually is \$60,760,000. The cooperative associations were found to be chiefly creameries, elevators, stock-shipping associations, stores, cheese factories, potato warehouses, and telephone companies. Surveys were also made of two rural communities to obtain statistical and descriptive analyses of economic, marketing, and social conditions. Further investigations were made of marketing of grain at Minneapolis, marketing meat, poultry, and butter, and the cooperative marketing of potatoes. For the most part these investigations have been practically completed and results are ready for publication. The same should be said for a preliminary study of rural credits in Minnesota. A study of egg marketing in the State was made showing the historical stages in egg handling from direct exchange of eggs for merchandise through a system of marketing by commission to a more or less elaborate method of selling on a cooperative plan. The chief danger of cold storage in eggs was found in the evil of selling storage eggs as fresh eggs.

The division of agricultural engineering devoted considerable time to a study of the value and methods of improving peat and muck lands throughout the State, and some positive information was obtained regarding suitable methods of preparing such land for cranberry culture.

The division of bee culture was established during the year and began work of both a research and practical nature with an equipment of 64 selected colonies of bees. Some attention was given to the problem of artificial fertilization of queens and apparent success was had in one instance. This was found to be a very difficult process on account of the danger of injuring the queen and, particularly, on account of the tendency of the workers not to accept the queens which had been artificially fertilized.

In the study of corn smut it developed that infections are somewhat local and that smut spores germinate very readily in favorable weather. An investigation of cucumber nubbin trouble seemed to indicate that this is a physiological disease. Rhizoctonia on potatoes was found to be more easily controlled by bichlorid of mercury than by other methods. A great difference in susceptibility of plums to brown rot is reported. The disease yielded to spraying applications made just before ripening.

Considerable attention was given to the examination of seed submitted by farmers. A method was perfected for the sure and rapid diagnosis between the various species of *Agropyron* seeds. A large number of cases of weed seeds were prepared and distributed to farmers.

Studies on wheat in storage were continued, attention being given to carload lots with moisture varying from 12 to 17 per cent. Interesting results were accumulated from the study of the sweating process in stored grain. A higher yield of flour was obtained from Marquis wheat than from Fife and Bluestem varieties, and the flour contained more protein, absorbed more water in making dough, and produced loaves of greater volume. The invertase content of flour proved to be so much less than that in yeast that invertase was not considered a factor in the strength of flour.

A method was perfected for the determination of organic acids in sorghum juice. On this basis a study was begun of the effect of these acids upon the process of manufacture and upon the quality of sorghum sirup.

Experiments in the preservation of eggs with sodium silicate were repeated during the year. Water glass on the Minnesota market proved to be practically all obtained from the same source, and of two or three grades, but limited in range of alkalinity. It was found that the deposition of sodium silicate from solution depends upon exposure to the air and carbon dioxid, and that the silicate may be redissolved by boiling with lye, after which it is equal to fresh solutions.

Many fertilizer experiments were carried on at the main station and substations, particular stress being placed on the fertilizer requirements of peat soils, and a survey is being made for the purpose of classifying the peat soils of the State.

The following publications were received from this station during the year: Bulletins 132, Studies in Egg Marketing; 134, Land Clearing; 135, Woodworking Exercises for the Agricultural School Shop; 136, Rope and Its Use on the Farm; 137, Minnesota Wheat Investigations, II; 138, A Study in Cereal Rusts—Physiological Races; and the Annual Reports for 1912 and 1913.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act      | \$15,000.00 |
| United States appropriation, Adams Act      | 15,000.00   |
| State, miscellaneous, including substations | 366,068.54  |
| Total                                       | 396,068.54  |

The station now has well in hand the urgent problems of Minnesota agriculture. The State has generously provided funds for work on these numerous problems, and the reorganization of the staff of the station is well designed to enable experiments to be carried on most effectively.

#### MISSISSIPPI.

*Mississippi Agricultural Experiment Station, Agricultural College.*

E. R. LLOYD, M. S., *Director.*

The State legislature voted a somewhat larger appropriation for demonstration work at the substations but no additional appropriation for the college station, which received, however, \$1,000 for the publication of popular bulletins. The appropriation for tick eradication and hog-cholera work was not put under the charge of the station. J. M. Beal was appointed plant pathologist in the station and the connection of A. B. McKay as horticulturist was terminated during the year.

*Adams fund projects.*—The Adams fund project on mule breeding was carried forward in a systematic manner. The animals used in this experiment now number about 150. A large mass of data has been accumulated, and the records are being digested preparatory to publication. The work has attracted much attention throughout the State and country generally among animal breeders. The study of scale insects was continued actively. Some undescribed species were found, none, however, of serious economic importance. The records of material previously collected were systematically worked up during the year. The work on pecan insects took a similar course involving chiefly the identification of species previously collected. Experiments in methods of control have not yet been undertaken. The bean leaf beetle occurred only sparingly during the year and little opportunity was had to continue the study of this pest systematically. The investigation of the habits and methods of controlling crawfish was continued, and studies were made on some 400 crawfish holes, some of which were found to extend as deep as 18 feet.

On the subject of the bacteriological effect of green manures, some important information was brought to light. A type of poor soils was used in pot experiments in the greenhouse, in which alfalfa was

added with various amounts of limestone, cow manure, and horse manure separately, and the culture of agar containing the organisms ordinarily found in horse manure. The bacterial cultures gave much better results than the manure alone.

Encouraging progress was also made in the study of the inheritance of contrasted characters in cotton. The crosses used in this work were made between Upland varieties only. The characters studied are such as can be measured quantitatively; for example, length of staple, early productiveness, size of leaf surface, and yield. An attempt is being made to determine the coefficient of earliness. Cotton used in the work was grown both at the college and Delta stations. Considerable acclimatization work was also carried on in cooperation with the North Carolina station to determine the possible effect of exchange of seed and whether any mutations occurred under such conditions.

In a study of the methods of transmission of hog cholera it was found that the air has little to do with the transmission of this disease, no transmission being observed from sick to healthy hogs placed within a few feet of one another. No positive results were secured showing the association of lice in the transmission of hog cholera. Cowbirds, sparrows, pigeons, and blackbirds, however, were found to be capable of carrying the disease, and the study will be extended to buzzards and crows in this connection.

*Work with Hatch and other funds.*—With the aid of Hatch and other funds the animal husbandry department cooperated with a number of farmers in feeding beef cattle. The results proved satisfactory to all concerned. The station also cooperated with the Bureau of Animal Industry of this department in studying the problem of finishing beef cattle under farm conditions. This work was conducted on two farms. Cooperative feeding experiments were also carried out with 25 farmers for the purpose of determining the financial prospects of beef production in Mississippi.

Cottonseed meal was tested as a chicken feed in comparison with beef scrap and with various other sources of protein. No bad effects were observed from cottonseed meal either on young or mature birds. The experiments showed that cottonseed meal as a source of protein for poultry was satisfactory and profitable. The effect of cottonseed meal on the health and breeding capacity of cows was also investigated. The cows were fed cottonseed meal rations up to 5 pounds. This test has been carried on for five years and the results have indicated that heavy rations of cottonseed meal are injurious in several ways. In a few cases specific udder troubles were thought to be aggravated by cottonseed meal.

In fertilizer tests with cotton larger yields were obtained from planting in rows 3 feet apart than at any wider distance up to 5 feet.

Larger yields were also secured from planting 12 inches in a row than at a distance of 20 or 30 inches. The yield per acre was considerably increased when squares infested by the boll weevil were picked and destroyed, as compared with plats where such precaution was not taken. The investigation of the conditions and prospects of truck farming in the State led to the publication of a bulletin containing specific precautions and recommendations regarding the culture and marketing of the important truck crops. Among the miscellaneous lines of work carried on at the station were studies on Sudan grass, a plant-disease survey, a test of lime and rock phosphates on cotton land, cultural and variety tests of legumes and other forage plants, and an investigation of the cost of growing various forage crops.

The following publications were received from this station during the year: Bulletins 162, Cottonseed Meal as a Feed for Laying Hens; 163, Truck Crops for South Mississippi; 164, Cotton Experiments, 1913; Circulars, July, 1913, Diseases Prevalent Among Horses and Cattle in Mississippi; September 1, 1912, Report of Work on Alfalfa at Holly Springs Branch Experiment Station.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act | \$15,000.00 |
| United States appropriation, Adams Act | 15,000.00   |
| State appropriation for substations    | 33,525.00   |
| Farm products                          | 5,334.04    |
| Miscellaneous                          | 1,658.75    |
| Balance from previous year             | 1,617.02    |
| Total                                  | 72,134.81   |

The funds available to the Mississippi station have been used economically, and the results obtained by the work of the staff are exercising a noticeable effect in the improvement of Mississippi agriculture.

#### MISSOURI.

Missouri Agricultural Experiment Station, *Columbia*.

F. B. MUMFORD, M. S., *Director*.

The chemical department of the experiment station occupied its new quarters in Schweitzer Hall, a modern laboratory building with separate laboratories for determination of nitrogen and phosphorus, and also rooms for meat curing and refrigeration and the study of animal nutrition. The new plant for hog-cholera serum, for which an appropriation of \$50,000 was made by the State, will be located on a tract of 90 acres of land which will be devoted entirely to this purpose. A modern refrigeration plant will be constructed in connection with this institution. Remodeling and improvements were also effected in the sheep barn, horse barn, and dairy building.

The State appropriations included \$6,000 for a soil survey and \$10,000 for experiments with soils and crops. The station staff was strengthened by a considerable number of appointments, especially of assistants in animal husbandry, agronomy, farm management, and veterinary science. W. H. Chandler, assistant horticulturist, resigned his position. Steady progress was made in all lines of work. No essential new features of policy developed during the year. Efforts were made to devote most of the energies of the station to investigation along important lines of research rather than to less systematic experiments with miscellaneous problems.

*Adams fund projects.*—The investigation of the use of food by steers of given ages and conditions went forward with satisfactory results. Analytical work was completed on 300 samples of material from skeletons of experimental animals. The animals, which have been maintained on medium and low rations, such as are still alive, will be placed on heavy rations for the purpose of determining the composition of the increased weight. In this investigation it was found that as large calves were secured from heifers fed a medium ration as from those maintained in a fat condition.

Growing animals fed a ration deficient in calcium showed the typical effects of this deficiency. They were readily restored to a normal condition, however, by increasing the lime in the ration. While under artificial conditions it was found possible to devise a ration deficient in mineral matters, this proved to be a very rare occurrence under natural conditions of feeding. In related experiments to determine the effect of retarded growth on young steers the smallest ration was planned on as low a plane as was possible to use and keep the animals alive. Under such conditions animals proved to be susceptible to various ailments and diseases. Animals thus stunted will be retained on the low rations for one, two, and three years, and then placed on high rations to determine when the effect of stunting becomes permanent.

An investigation is being made of the effect of variation in moisture content on the roots, stalk, leaf, and other parts of corn. The critical time for moisture appeared to fall at the time when the ears are forming. Variations are also being made in the nutrients furnished the corn plants to determine the effect of this variation on the development of the corn crop.

In the study of age as a factor in animal breeding attention was centered chiefly upon sows. The prevalent opinion that early breeding may diminish the size of the breed is being carefully examined. Sows of different ages are bred and measurements taken of the mother and offspring up to nearly four years of age. Early breeding appears to have a stunting effect upon the mother, which is apparently permanent. Lactation, however, seemed to be a more severe

strain than pregnancy. The same was found true for heifers. Pregnancy did not retard growth in young sows, while lactation caused a decided check in the growth.

The influence of light on the host plant was carefully noted in a study of the relation of powdery mildews to their hosts. When the host plant is kept in the dark the incubation period of the mildew and the extent of infection were checked. In the absence of carbon dioxid infection was practically prevented. In these experiments wheat and barley were used chiefly, while observations were also made on mildew in several varieties of oats. Among 300 varieties of wheat in the experiment only 2 were found to be immune. Incidentally in connection with this work observations were made on smut of wheat and oats. It was found that when the soil was badly infected with the spores of wheat smut the subsequent crop will almost invariably show a high degree of infection.

The diagnosis of hog cholera by means of complement fixation was investigated, but no definite results were secured. Various organs and parts are being used to learn whether an antigen can be secured which will produce complement fixation.

A study of the effect of the nutrition of heifers during growth upon their later physiological activities made definite progress. Heifers maintained on a ration deficient in lime made normal growth for a time, but within a year showed lameness, loss of appetite, and other abnormal conditions which were corrected by restoring lime to the ration.

In further work on the factors influencing the chemical and physical composition of milk the influence of the ration of cows on the fat content of the milk received special attention. Underfeeding appeared to affect not only the percentage of fat but its composition. The influence of underfeeding was greater than changes in the kind of feed. An elaborate investigation was made of the difference in coloring matter in milk fat and whey. This difference involved an examination of the yellow and orange pigments of plants and animals. These pigments apparently fell into the two groups, carotin and xanthophyll, which are found in both plants and animals. The fat of cow's milk was found to owe its natural yellow color primarily to carotin and secondarily to xanthophyll, both of which are taken up from the food, secreted in the milk fat, and not synthesized in the body. The same pigments were found to be the basis of the yellow color of the body fat and of the skin secretions of cows. The yellow pigment of milk whey, on the other hand, was found to be lactochrôme.

In the study of inheritance in domestic animals crosses were made between Seabright Bantam and Rose-Combed Black Bantam and also between the Silver Spangled Hamburg and Brown Leghorn.

This work involved the microscopic study of the reproductive cells, an attempt being made to determine which are the so-called sex-linked characters.

The cause of dormancy in trees has not thus far been definitely determined. It was found that the breaking of dormancy or the rest period was due to the activity of the enzymes. The use of ether in forcing plants showed that this is one of the best agents for breaking the rest period. The study of the effect of varying nutrition upon orchard and small fruits yielded few positive results on apples. In a few instances it was found possible to force the trees into bearing. With strawberries acid phosphate used at the rate of 150 to 440 pounds per acre gave a profitable increase in yield. In most cases the acid phosphate in combination with sodium nitrate or dried blood increased the yield over that from either of the latter fertilizing materials.

*Work with Hatch and other funds.*—All of the departments of the station carried on experimental or research work under the support of Hatch and other funds. The work of the chemical department involved a great number of analytical determinations in connection with soil survey, fertilizer control, and other departments of the station. Work was also begun on tomato diseases, especially Fusarium wilt and leaf spot, and upon the common diseases of forest trees. In a study of the bacteriology of soils, experiments were made to determine the effect of carbon bisulphid and toluol on soil organisms, and in this connection bacteriological analyses were made of soils taken from the field plats. The bacterial flora was also determined in rotation plats which had been maintained for 25 years.

In the test of the value of corn silage for 2-year-old steers it was found that a ton of silage was equal to one-half ton of clover hay, and that a ton of dry matter in the form of corn silage yielded 50 per cent greater value than the same amount of dry matter in the form of shock corn. Cattle which received corn silage as the only roughage did not thrive well for a longer feeding period than 90 days. In fattening western yearling sheep, it appeared that a ration of shelled corn, clover hay, and corn silage was more economical than any other ration in the test. A comparison of corn and oats for work mules showed that mules which received corn and hay maintained health, appearance, and working powers as well as those which received oats and hay. Corn produced as much endurance in hard work during hot weather as did oats. In order to maintain their weight, at equal work, 3 per cent more grain was required in the case of oats than with corn. A comparison of various methods of preparing corn for steers showed the best results from finely-ground corn chop.

In a farm survey of Jefferson County, Mo., on land valued at about \$71 per acre, the disadvantages of tenant farming were found greatly to outweigh the advantages. While the tenant farmed more land with the same equipment and received a higher labor income and a larger net income per acre, he was found to keep less stock, to obtain a lower crop yield, maintain a low standard of living, to pay less attention to education, and to have less cash at the end of the year. A system of farm diaries was introduced among 46 farmers, who report directly to the station the economics of their farm operations. It was found that the average cost of keeping a work horse was \$88.33 per year, that the average cost of keeping a milch cow on a dairy farm was \$85.10 per year, for a brood sow \$21.95 per year, and 65 cents annually for a hen. It appeared that the time of man labor on the average farm was divided during the year so that 35.2 per cent was devoted to care of stock, 29.8 to the care of crops, and 35 to miscellaneous labor.

The soil-survey work of the station included five counties, the work being done in cooperation with this department. Rotation experiments on one series of plats were brought to a close of the twenty-fifth year of the work. The results are being summarized and digested for publication.

Numerous cooperative spraying experiments were carried on with the aid of a State appropriation. A study was also made of apple fruit buds to determine the possibility of forecasting the fruit crop by ocular and microscopic examination. Experiments were continued in breeding for hardy peaches and apples and in comparing the results of spring and fall planting of apple trees. Fourteen different materials were used in spraying apple trees, and in this work soluble sulphur was found to cause injury to the foliage and fruit of apples.

An elaborate study was made of the frost injuries to plant tissue. It was definitely determined that the killing temperature of plant tissue, which is destroyed at a relatively high temperature, may be reduced whenever the sap density of the tissue is increased. Slow wilting or partial withholding of water through a long period appeared to increase the resistance of tissue to low temperature. The killing temperature for peach blossoms when the tree is just coming into full bloom appeared to vary from 22° F. to 26° F. After the flowers had become pollinated, and from that time until the peaches were one-half inch in diameter, the fruit tissues continued to become more susceptible to frost. Further studies were made on the soluble materials in sap and the osmotic pressure of sap as related to the susceptibility of trees to frost.

A study of bud selection of strawberries showed that it was not possible to increase the yield by propagating plants from buds of

the most productive varieties. In the use of fertilizers in peach orchards, nitrogen was the only element to which the trees responded satisfactorily.

The entomological department devoted much time to the enforcement of nursery and orchard inspection. Work was also carried on with liquid and dust insecticides and several repellents in attempts to control the corn-ear worm. Spraying experiments in commercial apple orchards indicated a net profit of \$57.65 per acre, as compared with \$2.78 per acre on unsprayed trees.

Experimental operations with field crops were conducted on a rather extensive scale. The treatment of the seed of sweet clover with sulphuric acid was found to increase the germination decidedly. The productivity of the soil was maintained and financial profits assured by rotation of corn, oats, wheat, clover, and timothy, the timothy being manured at the rate of 7 tons per acre. In general it was found that manure applied continuously to cropped land pays financially. Timothy yielded perhaps the most profitable returns from heavy applications of manure. When cowpeas were grown with corn, either between or in the rows, no excessive reduction in the amount of nitrates was observed in the soil over that which occurs when corn or cowpeas were grown alone. More moisture was required with corn and cowpeas grown together than with either grown separately. An investigation of drainage upon prairies of northeastern Missouri indicated clearly that on low, wet land the use of tile was highly beneficial and profitable; on the heavy compact soils of the level prairie it was found necessary to place the lines of tiles at closer intervals, but even under these conditions tiling yielded a net profit.

The publications received from this station during the year were as follows: Bulletins 110, Forage Crop Rotations for Pork Production; 111, Report of the Director for the Year Ending June 30, 1912; 112, Corn Silage for Fattening Two-year-old Steers; 113, Commercial Fertilizers for Strawberries; 114, Corn versus Oats for Work Mules; 115, Rations for Fattening Western Yearling Sheep; 116, Inspection and Analyses of Commercial Fertilizers, 1913; and 117, Report of the Director for the Year Ending June 30, 1913; Research Bulletin 7, Nutrients Required for Milk Production; Index, Research Bulletins No. 1-3; Circulars 59 (revised), The Farm Adviser in Missouri; 61, Docking and Castrating Lambs; 62, The Chinch Bug and Its Control; 63, Inspection Service, Control of Insect Pests and Plant Diseases; 64, Directions for Testing Cream; 65, Advantages from Use of Pure Bred Ram; and 66, Cotton Seed Selection for Southeast Missouri.

The income of the station during the past fiscal year was as follows:

|  |                |
|--|----------------|
| United States appropriation, Hatch Act-----              | \$15,000.00    |
| United States appropriation, Adams Act-----              | 15,000.00      |
| State appropriation-----                                 | 24,151.22      |
| Fees, including balance from previous year-----          | 26,916.55      |
| Farm products, including balance from previous year----- | 16,845.68      |
| Miscellaneous, including balance from previous year----- | 17,287.92      |
| <br>Total-----   | <br>115,201.37 |

The affairs of the Missouri station are in a stable and prosperous condition. Its research work is of high grade and is yielding important results.

#### MONTANA.

*Montana Agricultural Experiment Station, Bozeman.*

F. B. LINFIELD, B. S. A., *Director.*

The work of the Montana station during the year resulted in distinct advances in all directions. The grain and seed laboratory constructed for the station filled an urgent need. About 2,000 samples of grass seed and grain were examined for purity and germinating power at the request of farmers throughout the State. A great amount of fencing and other improvements was added to the equipment of the main station and Fort Ellis farm. The number of demonstration farms was reduced, work being carried only at Twin Bridges, Ronon, Eureka, Glasgow, and Wibaux. Prof. Alfred Atkinson returned to the station as agronomist, and P. N. Flint was appointed animal husbandman, and Dr. Howard Welch veterinarian.

*Adams fund projects.*—Work on most of the Adams projects progressed satisfactorily. The study of the disintegration of Portland cement was continued and will involve in its further prosecution the cooperation of the engineering department. In the investigation of conditions which prevail in incubators as compared with those under hens in hatching eggs, particular attention was devoted to the determination of phosphorus and lime in eggs at the end of 10, 15, and 20 days of incubation. The ratio between lime and phosphorus was found to vary at different periods of incubation, and the experiment will therefore be continued. Analyses will also be made of the parts and organs of hatched chicks as compared with those which fail to hatch or which show constitutional weakness.

In the study of the origin and control of nitrate in soils the chemical and agronomy departments cooperated. A close relation was shown to exist between the nitrate content of the soil and the method of cropping. Moisture determinations were made every 10 days and also the temperature determination every day to a depth of 5

feet on the rotation, fallow, and manure plats. Further investigations on the effect of arsenicals on the bark of trees partly substantiated the results previously obtained by the Colorado station. Humidity was found to be an important factor in the injurious action of arsenicals. A large number of arsenical compounds were tested in this work, the results obtained in the field being checked by greenhouse experiments. The effect of adhesive substances added to the spray was also studied. Progress was made in the investigation of diseases of the apple tree, particularly upon apple canker and collar rot. The cause of the apple canker was determined, but not that of collar rot, which, however, proved to be infectious.

The study of the life history and means of control of the sugar-beet root louse yielded interesting and important results. Wingless female lice were found in the ground upon the roots of sugar beets, weeds, and grasses throughout the year. It was demonstrated that winged individuals are produced in the fall and migrate to cottonwood trees, upon which each female deposits a single winter egg in a crevice of the bark. The young louse hatching from the winter egg the following spring forms a gall upon the cottonwood tree in which a single generation of lice is produced, all of which are winged, become summer migrants, and fly away to beets, weeds, and grasses, on the leaves of which they give birth to the young, which descend to the roots and start new colonies. It was found to be a comparatively easy matter to control this pest by proper irrigation. The life history of the oyster scale under Montana conditions was worked out, and spraying experiments begun to develop a satisfactory means of control.

Some progress was made in the study of the transpiration of water by wheat, oats, and barley. In these experiments the results obtained in the field were checked by the results secured in special tanks. The correlation studies in the selection of oats and wheat, carried on in duplication of work done at the Cornell station, also progressed satisfactorily.

*Work with Hatch and other funds.*—With the support of Hatch and other funds a wide range of study was carried on. Some attention was given to infertile soils, samples of which were collected from various parts of the State and are being studied by means of pot experiments. The relative infertility is shown to have been due to various factors. A chemical investigation was made of the changes which occur in ensiling clover. Second-crop clover ensiled in September kept well until May and June, but soon became discolored in warm weather. Clover silage was relished by cattle during the winter months but became unpalatable in warm weather.

Among the diseases observed on potatoes those caused by *Fusarium* appeared to be the most serious. The *Fusarium* dry rot was common

in stored potatoes. Experiments in the fruit districts indicate that plum pocket disease is readily controlled by lime-sulphur wash. A survey of the apple scab situation in Montana showed that this disease appeared in the State in 1900 and has gradually spread throughout all fruit districts. It was found to be easy of control by lime-sulphur, which also destroyed the oyster-shell scale.

In the field of horticulture variety and cultural tests were made with vegetables. The premature seeding of celery was studied, and practical observations made on fruit and ornamental trees. Variety testing was begun with potatoes as a basis for seed selection.

The department of agronomy carried on variety tests with wheat, oats, barley, flax, fall wheat, peas, and various other field and forage crops. Fertilizer experiments, especially with acid phosphate, were conducted on plats of grain, clover, and other crops, and more than 7,000 moisture determinations were made in connection with this work. In order to succeed in flax production it was found that the soil must be put in the best of tilth and that seed must be thoroughly graded and treated with formaldehyde before planting.

A farm management survey of the State was begun. Cost accounting projects were put in operation on 15 farms. Along the line of animal industry particular attention was given to the study of forage plants for pigs, testing ground flaxseed as a ration for dairy cows, the determination of the cost of beef production, and various feeding experiments with beef cattle, involving the use of local grain products and straw or hay. In feeding horses it was found desirable to restrict the hay ration, whether timothy or clover, in order to secure the best results. Clover hay proved as satisfactory as timothy hay when fed in rations of not more than 1 pound per day. The best results were obtained with horses doing light work when they received not more than three-fourths pound of hay daily. A feeding test was made with clover hay and clover silage in milk production. On clover hay the cost of producing milk was 73.9 cents per hundred pounds. In milk production 1 pound of clover hay was equal to 2.33 pounds of silage, the silage appearing to have a value of \$2.55 per ton.

The entomological department made observations on a variety of miscellaneous insects including mites, grasshoppers, plant lice, cutworms, wireworms, and the spotted-fever tick, and also upon methods of destroying prairie dogs and ground squirrels.

The veterinary department began a study of hog cholera, particularly its distribution in the State and method of treatment. Experiments were also begun in feeding calves on milk treated with formalin.

Pruning experiments with tomatoes demonstrated that pruning alone will increase the yield of ripe fruit greatly and somewhat ad-

vance the season of maturity. Thinning potatoes on irrigated land reduced the total yield but increased the amount of marketable potatoes and reduced the amount of culls 50 per cent.

The publications of this station received during the past fiscal year were Bulletins 92, Tenth Annual Report of the State Entomologist of Montana; and 93, Fergus County Substation Report on the Work and Plant; Circulars 20, The Control of Prairie Dogs and Ground Squirrels; 21, The Roller or Packer; 22, Cropping to Flax on New Lands of Semiarid Land Areas; 23, Creamery Organization and Management; 24, Measurement of Water; 25, Cabbage and Cauliflower in Montana; 26, Celery Culture in Montana; and 27, Cooperation for Better Farming with County Agriculturists; and the Annual Report, 1913.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act | \$15,000.00 |
| United States appropriation, Adams Act | 15,000.00   |
| State appropriation                    | 31,342.03   |
| Individuals                            | 1,045.36    |
| Farm products                          | 6,111.05    |
| Total                                  | 68,498.44   |

The station is constantly improving its organization and effectiveness. The grade of scientific work has been decidedly elevated and the amount of important published material has increased.

#### NEBRASKA.

Agricultural Experiment Station of Nebraska, Lincoln.

E. A. BURNETT, B. S., Director.

Notwithstanding the fact that an extraordinary drought occurred during the summer and fall of 1913, greatly interfering with field work in agronomy, the progress of investigations at the Nebraska station as a whole was marked. About \$20,000 of State funds were available to the station for investigation purposes. In addition to this sum the appropriations for substations amounted to \$47,750. A dairy barn (Pl. VI, fig. 2) was erected at the North Platte substation and also new buildings for use in serum production at a cost of \$10,000. Dr. F. J. Alway, chemist of the station, resigned and his place was taken by Dr. F. W. Upson. Several other appointments and minor changes in the staff occurred.

*Adams fund projects.*—The study of the chemical factors concerned in the formation of pigments in corn was continued, attention being devoted chiefly to purple, self-red, and brown. The amount of material available for this work during the season was somewhat limited, but it was quite definitely determined that the dark purple color is due to the presence of glucosid and that the self-

red color is probably due to the presence of the same substance in less amount. An investigation was begun on the relation of oxidizing enzymes in the production of color.

It was found that marked differences occur in different varieties of sorghums and corn in regard to the formation and persistence of hydrocyanic acid. In this work 25 varieties were studied and they show a wide range of hydrocyanic acid. A study has been begun on the relation of nitrogen nutrition to the content of hydrocyanic acid. In the study of the water soluble potash and phosphorus in the transition soils, the conclusion was reached that these substances increase in a quite regular ratio from east to west in the first 6 feet of soil.

The study of inheritance of pigments in corn was continued actively. The variation was found to be connected with the development of a dark-red pigment in the pericarp of the corn kernels. Experimental results indicated that the more color in the pericarp of the seeds planted the more likely they were to produce plants with wholly self-red ears, and the less likely to produce plants with variegated ears. Self-red ears thus produced behave in inheritance as if they were hybrids between self-red and variegated races or between self-red and nonred races of corn. The study of winterkilling resolved itself largely into an investigation of the water content of apple trees and raspberry canes during the winter and of means of conserving this water content. The winterkilling appeared to be due primarily to the drying out of the canes.

Continuing the experiments on the water requirements of crops, the department of agronomy made use of 90 potometers, a single plant being grown in each can. These cans held from 50 to 1,200 pounds of soil. The influence of soil fertility on the amount of water used up by the plants is being studied. It has already been found that increasing the fertility brings about an increase in the total amount of water required by the plant.

In a study of the insect visitors of alfalfa, bees were found to be by far the most important insect. Further studies will be made to determine what other species are regular visitors and how many visitors are concerned in the pollination of alfalfa.

A large amount of attention was given to the study of potato diseases, such as stem-end rot, leaf curl, leaf roll, and rosette. Some evidences are obtained of individual resistance to certain of the diseases, especially to leaf curl. The blister canker of apple trees, due to *Nummularia discreta*, received considerable attention at Arlington, Nebr., where a cooperative experiment is in progress to determine means of controlling this disease.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds the horticultural department carried on experi-

ments in the control of blister blight, cultural methods for potatoes, breeding apples for hardiness, and on the conditions essential to success with vegetable gardens in western Nebraska. Variety tests were also made with 80 strains of Turkey Red wheat, and some breeding and cultural work was carried on with barley, emmer, soy beans, and miscellaneous forage crops. A study is also being prosecuted on the anatomy and physiology of the potato plant. The engineering department began experiments on the draft of wagons, the construction of hog houses, methods of handling silage, and testing the efficiency of irrigation pumps.

The dairy department continued a study of the cost of milk production, and also accumulated numerous important data on the value of corn and alfalfa silage, cooperative creameries, and the cost of raising cows. A review of the yield of the college herd for 14 years showed that the average production per cow per year was 341.71 pounds of butter. This yield was nearly three times the average yield throughout the State and was produced from locally-grown crops. The animal industry department devoted attention particularly to a comparison of soaked, ground, and whole wheat for pigs, and to the general problem of beef production in the State. The production of hog-cholera serum occupied most of the activities of the veterinary department during the year.

An investigation of soil-moisture conditions at the North Platte substation showed that the maximum amount of moisture which these soils will hold under field conditions is 18 per cent, and that the minimum point of moisture at which crops can use the water is 7 per cent. Summer tillage proved to be the most efficient means of storing water in the soils, from 10 to 33 per cent of the seasonal rainfall being conserved by this means. A number of plants were grown in water-tight cylinders, 6 feet long and holding 100 pounds of soil, to which the desired percentage of moisture was added, the plants being allowed to grow until they matured or died without further moisture. In this experiment it was shown that the soil water available to plants is approximately equal to the free water, or the difference between the total water and the hygroscopic water of the soil.

The publications of this station received during the past fiscal year were as follows: Bulletins 138, Silo Construction in Nebraska; 139, Dairy Herd Records for Fourteen Years; 140, The Storage and Use of Soil Moisture; 141, Irrigated Field Crops in Western Nebraska—Report of the Scottsbluff Experimental Substation, Mitchell, Nebr.; 142, Vegetable Gardens on Irrigated Farms in Western Nebraska—Report of the Scottsbluff Experimental Substation, Mitchell, Nebr.; Research Bulletins 3, Studies on the Relation of the Nonavailable Water of the Soil to the Hygroscopic Coefficient; 4, The Inheritance



FIG. 1.—OFFICE BUILDING, NORTH PLATTE SUBSTATION, COST \$8,000, NEBRASKA STATION.



FIG. 2.—CONCRETE DAIRY BARN, NORTH PLATTE SUBSTATION, NEBRASKA STATION.



FIG. 1.—TIMBERLINE FOREST ON MOUNT ROSE, APPARATUS FOR SAMPLING SNOW,  
NEVADA STATION.



FIG. 2.—GASOLINE LAUNCH USED IN MAKING METEOROLOGICAL OBSERVATIONS ON LAKE  
TAHOE, NEVADA STATION.

of a Recurring Somatic Variation in Variegated Ears of Maize; and Annual Reports, 1912 and 1913.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----            | \$15,000.00 |
| United States appopriation, Adams Act-----             | 15,000.00   |
| State appropriation, including amount used for sub-    |             |
| stations -----   | 67,750.00   |
| Miscellaneous, including balance from previous year--- | 51,365.61   |
| Total-----   | 149,115.61  |

The station is gaining steadily in support from the State legislature and in sympathy from the farmers of the State. Its work is meeting the requirements of Nebraska agriculture.

#### NEVADA.

Nevada Agricultural Experiment Station, Reno.

S. B. DOTEN, M. A., *Director.*

Several changes in the staff occurred during the year, making necessary a considerable readjustment and reorganization of the work of the station. S. B. Doten succeeded G. H. True as director of the station. C. S. Knight returned to the station as agronomist, Dr. P. B. Kennedy resigned as botanist and horticulturist, and Leslie T. Sharp resigned from the soils laboratory. No new buildings were erected during the year, but improvements were made on the old main building. The president of the university, Dr. J. E. Stubbs, who had long been director of the station, died on May 7, 1914.

*Adams fund projects.*—Work was continued on the study of the genus *Trifolium* from a botanical and agricultural standpoint, with the main object of determining the botanical relations of the genus from seed to mature plant. On account of the resignation of Dr. Kennedy this project was transferred to the California station. Further investigations were made on the hymenopterous parasites of the codling moth. During the year attention was confined largely to a study of the food of certain species of these parasites. It is hoped to discover the relationship between the codling moth and the various primary, secondary, and tertiary hymenopterous parasites which occur in Nevada.

Interesting facts were brought to light from the investigation of the relation of nitrogen to the organic constituents of alfalfa. This study is designed to furnish an explanation of the fixation of atmospheric nitrogen by leguminous plants, and to follow the transformation of nitrogen from the atmospheric form to the more complicated organic structures in the plant substances. During the coming year attention will also be given to enzymes and saponins in alfalfa hay.

The poisonous principle of water hemlock was isolated and its toxic properties are being definitely determined by experiment. The active principle was isolated in a noncrystalline form and determinations of its molecular weight made. The species to which attention was chiefly confined was *Cicuta occidentalis*. The yield of the yellowish, viscid, resin-like, poisonous principle was 0.3 or 0.4 per cent of the weight of the green tubers. The lower portion of the stems also contained some of the poisonous substance and the leaves a still smaller proportion. A reliable chemical test for the detection of the poison was worked out. The active principle, known as cicutoxin, was shown to be an unstable, resin-like substance, which readily decomposes at temperatures above 50° C. The poison acts upon the spasm nerve center in the brain, causing paroxysms, followed by a paralytic stage. No antidote has thus far been found. It was shown that a portion of the root of the size of a walnut was sufficient to kill a cow and that 150 to 200 milligrams of cicutoxin was a fatal dose for a rabbit or a cat.

The investigation of pine oils is directed largely to a study of the terpenes contained in *Pinus monophylla* and *P. jeffryii*. It was found that in the latter species the volatile oil is chiefly pentane and not a terpene.

But few cases of equine anemia occurred during the year, and the opportunity for studying this disease was therefore limited. Two inoculated horses died, thus affording opportunity for a study of the pathology of the disease. It is hoped to obtain information during the coming year on the etiology of equine anemia, so that a logical method of control may be worked out.

Observations were continued on the water-conserving power of pine and fir forests. An unusually heavy precipitation occurred during the year, yielding valuable data in determining the effect of forests in conserving deep and shallow snows. Special evaporation pans were devised to determine the rate of evaporation of snow under trees. It was shown that in forests a much larger accumulation of snow occurs than on bare slopes and that the amount retained varies according to the predominant species of trees in the forest. Fir and pine proved superior to other kinds of trees in conserving snow. On account of the great importance of knowing in advance the relative water supply for irrigation which is stored in the mountains in the form of snow, special methods were devised for giving more accurate information as to the quantity and density of the snow deposits on the mountain slopes. A snow sampler (Pl. VII, fig. 1) was perfected for obtaining snow samples to a depth of 20 feet. It was definitely shown that on forested slopes the snow is better conserved, the melting occurs later in the season, and the distribution of the run-off is better regulated.

*Work with Hatch and other funds.*—With the aid of Hatch and other funds a number of lines of work were carried on, including a study of the planting time of sugar beets, variety tests with various grains and root crops, methods of irrigating clover, alfalfa, sugar beets, potatoes, and wheat, using 2, 4, or 6 inches of water at each application. The purpose of the irrigation experiment is to determine the critical stages for each crop at which the growth of plants is injured unless water is applied at once. Studies were continued on cutworms in alfalfa fields and upon the injuries due to the European elm scale. Methods of controlling chicken cholera were investigated. Several outbreaks of hog cholera offered opportunity for a test of serum. The further study of chicken cholera will involve the possibility of the determination of immunity, the duration of such immunity, and the value of other methods for controlling the disease.

It was found that sugar beets planted from April 20 to May 20 produced the heaviest yields, the maximum yield being 20.79 tons per acre. Variety tests with potatoes gave results in favor of home-grown seed. In irrigating oats it was found that the greatest benefit was received from two irrigations before and three after heading, and with wheat the heaviest yield per acre-foot of water was obtained with one irrigation before and one after heading.

The publications received from this station during the year were as follows: Bulletin 80, Food and Drug and Weight and Measures Laws of the State of Nevada, with the Rules and Regulations Adopted for the Enforcement of the Same; and the Annual Report for 1913.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----               | \$14,275.00 |
| United States appropriation, Adams Act-----               | 13,516.70   |
| Balance from United States appropriation, Hatch fund----- | 725.00      |
| Balance from United States appropriation, Adams fund----- | 1,483.30    |
| State appropriation-----                                  | 4,550.00    |
| Farm products, including balance from previous year-----  | 468.61      |
| Total -----   | 35,018.61   |

The readjustment of the lines of work prosecuted by the station is calculated to bring the station into closer contact with the essential problems of Nevada agriculture.

#### NEW HAMPSHIRE.

New Hampshire College Agricultural Experiment Station, Durham.

J. C. KENDALL, B. S., *Director.*

The chief efforts of the New Hampshire station during the year were devoted to researches involved in Adams fund projects. An

orchard was rented adjoining the Woodman experimental orchard for testing the value of fertilizers applied to orchards under sod and sod mulch. The insectary was inclosed in glass, so that it could be used as a greenhouse in winter, thus permitting more continuous work with some of the lines of study. A set of orchard heaters was added to the equipment of the horticultural department. The extension work was organized along independent lines, thus relieving the station workers of miscellaneous activities which had previously interfered with their investigation. There was no increase in the staff during the year.

*Adams fund projects.*—The seventh year of work on the study of fruit-bud formation in apple trees was completed. It was shown that the yield of Baldwin apples in "off" years could be improved by good cultural methods and that the formation of axillary fruit buds in the current season's growth is not uncommon. Apple trees in heavy bearing suffered materially when the moisture content fell to 6½ to 7 per cent in sandy soil and 12 per cent in a loam soil. The moisture under sod was found to be a little higher than where clean culture was practiced, but nitrates in the soil were greatly reduced under sod. The daily twig growth showed a close correlation with the yielding power of the trees. A heavier deposition of reserve food material in the tissues was found when the tree had formed fruit buds. The specific gravity of the twigs and branches in winter condition where fruit buds had been formed was 4 per cent greater than on trees which did not show fruit buds. Incidentally it appeared that the use of fertilizers in the production of apples brought no financial profit. A good system of cultivation yielded as satisfactory results as the application of a complete fertilizer. In some cases the size of the fruit was increased by the use of fertilizers, but the color was not affected by any combination of fertilizers.

In continuing the study of squash breeding two generations of pure strains and reciprocal crosses of Delicious and Warren were grown in the greenhouse. The results of this work are still to be digested and tabulated. In connection with squash breeding some work was done on melons, during which six pairs of characters were studied. In this study it appeared that the characters show a blend in the first generation and a segregation into dominant and recessive characters during the second generation. Yellow color of skin was dominant over green, round form of fruit over obtuse-elliptical, large size of seed over small size, ribbing over nonribbing, netting over smoothness, and large size of fruits over small size. The work on carnation breeding was confined to the self-fertilization of plants to determine the purity of strains.

In a study of point rot or blossom-end rot of tomato it was found that this disease is not due primarily to bacteria or fungi. Plants

appeared to be most susceptible when growing most actively. Excessive watering or a sudden check in the water supply sometimes produced the disease. Potassium chlorid increased the tendency to disease, while nitrate of lime and soda diminished it. The liability to blossom-end rot was also increased by applications of stable manure, ammonium sulphate, dried blood, cottonseed meal, or a rise of soil temperature. It was found that susceptible tissue contains more starch and oil than normal tissue.

The investigation of the availability of potash in clay soils showed that New Hampshire soils are rich in potash, which occurs as clay and in mineral form. The mineral forms of potash were shown to have a definite solubility in water, which was increased by fertilizer salts. Calcium carbonate had no effect on the solubility of soil potash, and no new soluble salts appeared in the solution when potassium phosphate was added to the soil. The solubility of the soil potash was greatly increased under the influence of chlorid, nitrate, or carbonate of soda. It appeared that the use of potassium fertilizers on these soils was unprofitable, at least in the production of hay, as well as of several other crops.

The habits and life history of the apple maggot were carefully worked out and the bearing of these facts upon methods of control was considered. The food plants of the apple maggot proved to be apple, grapes, haws, huckleberries, and blueberries. In New Hampshire the adults emerged at the end of June or beginning of July, and only one brood occurs annually. In connection with the pupal stage the interesting finding was made that the apple maggot may follow a one-year or a two-year life cycle, the pupal stage occupying about 300 days in the one-year life cycle, while a few of the individuals require an extra year for the pupal stage. It was found that fruit must reach a stage of rather complete mellowness before the larvae can mature and leave it. The prompt collection and destruction of fallen apples thus appears to be a simple means of controlling the apple maggot. A beginning was also made on the study of the effect of insecticides upon root maggots. A considerable mass of data was accumulated regarding the penetration of different insecticides in the soil and the effect of these insecticides upon root maggots. A mass of temperature records and observations on the relation of temperature to insect life were also published.

Much difficulty was experienced in the proper installation and regulation of apparatus for use in studying water as a limiting factor in the growth of corn. The results obtained during the year was therefore of a preliminary nature and the investigation will be continued.

As a part of the results of the investigation of sheep breeding the station now has 123 head of mature sheep, 34 of which are first and

second generations of crosses between the Hampshire and Rambouillet breeds. Complete records have been kept of the inheritance of color on face and legs, wool covering on face and legs, skin folds, and quality of wool. During the year 1914 Rambouillet ewes were added to the station flock and were mated to a pure-bred Southdown ram. In this cross a study will be made of the inheritance of the weight of fleece, of grease in the wool, and of the general body form. Attention is also being given to comparison of the hereditary characters of twins and their progeny to the inheritance of supernumerary mammae and short ears.

In connection with a study of the effects of fungicides and insecticides on plants a physicochemical examination was made of Bordeaux mixture, during which it was found that the Bordeaux mixtures commonly used are of one or another of three types—neutral, slightly alkaline, and strongly alkaline or basic. Bordeaux mixture was shown to be composed of one or several basic cupric sulphates or mixtures of basic cupric sulphates, depending upon the ratio of basic cupric sulphate to calcium oxid used in the preparation of the mixture. The physical state of the copper precipitate found in Bordeaux mixture was shown to depend partly on the dilution of the salts and the manner in which they were brought together and on the temperature of the water.

*Work with Hatch and other funds.*—Various lines of work were carried on under the support of Hatch and other funds. In the horticultural department variety tests were made with apples, plums, and small fruits, and observations were made on the methods of handling and propagating native blueberries. Some of the best strains were selected for a further study and hybridization. Cooperative experiments were also conducted in different parts of the State with cover crops for orchards and a number of tests were made to learn the effect of thinning apples.

In the study of the effect of temperature on storage of potatoes it appeared that the loss of weight decreases when germination is retarded by reducing the oxygen supply or lowering the temperature. Tubers held under the former condition lost 4 per cent less weight in 205 days than potatoes kept in the air at the same temperature. At a temperature of 38° F. potatoes kept well for 160 days, after which the sprouts began to swell.

The agronomy department carried on fertilizer tests with potatoes, comparing manure and artificial fertilizers, home mixing and factory mixing of fertilizers, the use of nitrate of soda on clay soil for the production of hay, and variety tests with alfalfa. Grimm alfalfa gave the best results, yielding 4½ tons per acre in three cuttings and resisting frost better than other varieties. An examination was made of numerous samples of seed submitted to the station, during which

the relative freedom from weed seed and the percentage of the germination were determined. Among other lines of work carried on at the station mention should be made of the use of miscible oils on streams to destroy black flies, the inspection of fertilizers and feeding stuffs, and a feeding experiment with sheep to determine a suitable winter ration for breeding ewes.

The following publications were received from this station during the year: Bulletins 163, Twenty-third and Twenty-fourth Reports, 1911-12; 166, Results of Seed Tests for 1913; 167, The Fertilizer Inspection for 1913; and 168, The Effects of Fertilizers in a Cultivated Orchard.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----              | \$15,000.00 |
| United States appropriation, Adams Act-----              | 15,000.00   |
| Farm products-----                                       | 3,445.53    |
| Miscellaneous, including balance from previous year----- | 9,363.05    |
| Total-----   | 40,808.58   |

The efficiency of the work of the station was materially increased by a fine spirit of cooperation and mutual helpfulness among the members of the staff. The scientific work has also been improved by a more systematic organization of the energies of the station upon definite projects.

#### NEW JERSEY.

New Jersey State Agricultural Experiment Station, New Brunswick.  
New Jersey Agricultural College Experiment Station, New Brunswick.

J. G. LIPMAN, Ph. D., Director.

The land area at the disposal of the station and college was increased by the purchase of several small tracts and by securing the use of 32 acres of land for the study of oyster problems. The new agricultural building (Pl. III, fig. 2) was completed at a cost of \$100,000, with an additional expenditure of \$20,000 for equipment. The ground floor of this building gives office space for the director and horticulturist. Several appointments were made during the year, most of them being assistants in connection with the several departments of the station. The State appropriations to the station for the year included \$25,000 for salaries, \$30,000 for mosquito extermination, \$6,500 for poultry work, \$3,000 for floricultural investigations, \$5,000 for printing bulletins, \$2,000 for seed control, and \$1,500 for repairs on the experiment-station building.

*Adams fund projects.*—Considerable progress was made in the study of the availability of nitrogenous fertilizer materials and the accumulation and utilization of atmospheric nitrogen. Work on the

latter project was continued with eight types of New Jersey soils in a four-year rotation. On shale soil and combinations of shale soil with sand up to 70 per cent, the average availability of dried blood proved to be 70 when nitrate of soda was rated at 100. The average percentage of nitrogen in the dry matter of crops grown with nitrate of soda was higher than in crops fertilized with dried blood. In growing cereals continuously on the same land as compared with a system of rotation, including in some cases legumes, it was found that the yields of grain were about twice as large on plats on which the preceding crop was a legume as on plats without a legume in the rotation. The application of small quantities of cow manure appeared to be instrumental in bringing about a more rapid decomposition of the green manure crop, thus making available more nitrogen for the succeeding crop. The results of seven years' experiments indicated clearly that leguminous green manuring crops were more effective in maintaining the nitrogen supply of the soil than was nitrate of soda at the rate of 160 pounds per acre or stable manure at the rate of 15 tons once in two years.

In rotation experiments with corn, oats, wheat, and grass the results indicated a higher availability of nitrogen in the form of calcium and sodium nitrate, ammonium sulphate, and calcium cyanamid than for nitrogen in the form of dried blood, fish, and concentrated tankage. In connection with these experiments a comparison was made of magnesian and nonmagnesian limestone. The yields from most crops were higher from the use of magnesian limestone, but both forms of limestone increased the yield of most crops except potatoes. In a study of ammonification of dried blood, cottonseed meal, and other organic forms of nitrogen it was found that a number of fungi were chiefly responsible for the large accumulations of ammonia in the soil. These experiments were carried on with pure cultures and all species of fungi used in the experiment, with a single exception, increased ammonification.

The investigation of the inheritance and correlation of structural character in crosses was continued on peppers, tomatoes, beans, and other garden plants. The shape of tomato fruit was found to be due to the interaction of a few factors rather than of a multitude of factors for specific sizes and shapes. In peppers it appeared that in the first generation there was a blending of nearly all the characters except the color pattern. No segregation of types appeared in hybrid okra, the successive offspring having persisted as an intermediate form for four years.

Influence of environment on plant growth was studied largely in greenhouses with cowpeas, soy beans, and a number of other crops. The variation in the length of hypocotyl appeared to be associated

with the length of the various internodes. In the case of corn it appeared that the kernels borne a short distance above the base of the ear were the first to form and proved to be the largest and capable of producing the most vigorous growth.

The toxic effect of definite amounts of salts upon the development of plants was studied in pot experiments in the greenhouse with buckwheat, beans, and corn. The effect of various quantities of sodium, potassium, calcium, and ammonium salts were studied, but the optimum amounts of these salts has not yet been determined. The effect of physiological conditions upon the growth of plants was studied largely in experiments with sweet potatoes, and it was found that when sweet potatoes were planted in soil sufficiently poisonous to the roots to allow of only initial growth, the plant deposited starch in the basal part of the stem. When sweet potatoes were planted in soil permanently covered with standing water, numerous roots grew upward to the surface of the water.

*Work with Hatch and other funds.*—All of the departments of the station participated in work under the support of Hatch and other funds. The poultry investigations included observations on the value of sour milk, ash, and protein in poultry feeding and a study of inheritance of egg production. For growing chicks it appeared that ordinary sour milk was better than milk soured with *Bacillus bulgaricus*. Proteins from a vegetable source, even when accompanied with a high phosphoric acid content in the ration, were not as efficient as when supplemented by some form of animal protein. Phosphoric acid from animal bone proved to be far more efficient than when derived from an inorganic source. Lime added to the ration had little or no effect upon the assimilation of nitrogen. As a result of four years' work in breeding for egg production, a record of 260 eggs per year from one hen was obtained.

In the horticultural department a study was made of the effect of lime of various forms upon the growth and behavior of roses and carnations. The rose was found to be particularly susceptible to soil acidity. Much information was accumulated from the peach work at Vineland regarding problems of winter and summer pruning, the relation between the number and yield of fruit, and the effect of pruning on the yield of trees.

The entomological work involved extensive mosquito studies, experiments with liquid and dry insecticides, observations on a large variety of Diptera as related to the transmission of typhoid, and a study of peach borers and bee diseases. Extensive operations were undertaken in systems of drainage and other methods of control for the salt-marsh mosquitoes and in the study of the migration of these pests. In spraying experiments with combined fungicides and in-

secticides it appeared that some stimulation of potatoes was observed from spraying with Bordeaux mixture. The entomological department, in addition to its experimental work and other control work, made an inspection of 130 nurseries.

In connection with a nursery inspection for plant diseases throughout the State the plant pathologist began a plant-disease survey. Some attention was given to crown gall, peach yellows, little peach, chestnut blight, and potato scab.

The principal work of the department of animal husbandry included a study of economical methods of swine production, methods of feeding alfalfa and corn silage for milk production, and a study of the cost of raising heifer calves by different systems of feeding. A feeding experiment was begun for the purpose of comparing soil-ing crops with dry roughage as affecting milk production and as influencing the rate of growth of calves and yearlings.

The attention of the station chemist was largely occupied with an inspection of fertilizers, feeding stuffs, insecticides, and agricultural limes.

Observations were continued on the spawning and spatting of oysters for the purpose of determining the laws which control these processes. It was found that cold weather occurring at the time when the oyster spawn is usually ejected greatly reduced the extent of spatting and caused the spat to be less vigorous than usual.

The following publications were received from the station during the year: Bulletins 256, Concentrated Feeding Stuffs—Feeding Stuffs Law of 1912 and Registrations; 257, Conditions Affecting the Availability of Nitrogen Compounds in Vegetation Experiments; 258, Experiments on the Accumulation and Utilization of Atmospheric Nitrogen in Field Soils; 259, Analyses and Valuations of Commercial Fertilizers, Fertilizer Supplies, and Home Mixtures; 260, Field Experiments on the Availability of Nitrogenous Fertilizers; 261, Analyses and Valuations of Commercial Fertilizers and Ground Bone; 262, Analyses of Materials Sold as Insecticides and Fungicides; 263, Report of the Director, 1913; 264, Fertilizer Registrations; 266, Results of Seed Inspection, 1913; Circulars 7 (rev.), Dairy Feeding and the Home Mixing of Feeds; 23, Winter Egg Production; 24, The Home Preparations of Lime and Sulphur Mixtures; 26, Soil-infesting Insects; 27, Cowpeas for Soil Improvement; 28, Crimson Clover; 29, Peach Leaf Curl; 30, Apple Growing in New Jersey; 31, The Establishment of an Apple Orchard; 32, Diversified Poultry Farming; 33, Potato Diseases in New Jersey; 34, Crown Gall and Hairy Root; 35, Some Diseases of Nursery Stock; 36, Grain Smuts—Their Causes and Treatments; and the Annual Report for 1912.

The income of the station during the past fiscal year was as follows:

State station:

|  |             |
|--|-------------|
| State appropriation (fiscal year ended Oct. 31,<br>1914) ----- | \$72,043.57 |
| Fees -----   | 37,448.68   |
| Farm products-----   | 14,814.90   |
| <hr/>  |             |
| College station:   |             |
| United States appropriation, Hatch Act-----                    | 14,998.00   |
| Balance from United States appropriation, Hatch<br>fund-----   | 2.00        |
| United States appropriation, Adams fund-----                   | 15,000.00   |
| Miscellaneous-----   | 285.00      |
| <hr/>  |             |
| Total-----   | 154,592.15  |

The New Jersey stations have a strong hold upon the people of the State by virtue of the numerous practical activities with which they have been entrusted. The investigational work of the stations is concentrated upon a few lines and is yielding satisfactory results, particularly in knowledge of soil fertility.

NEW MEXICO.

*Agricultural Experiment Station of New Mexico, State College.*

*FABIAN GARCIA, M. S. A., Director.*

The work of the station progressed and resulted in a number of important contributions to the agriculture of the State. The present director assumed his duties with the beginning of the fiscal year. H. H. Simpson resigned as animal husbandman, and his duties were assumed by Luther Foster. Other staff changes of minor importance were made.

*Adams fund projects.*—A study of methods of improving the Mexican chili has been practically completed. Several good strains were produced during the progress of this work and are ready to be distributed for general planting throughout the State. The investigation of chili blight indicated that the disease is probably caused by Fusarium. Inoculation experiments with this organism, however, gave negative results.

Work on the biology of the codling moth was actively continued. It was found that the broods in New Mexico overlap one another very irregularly. The first brood of moths was shown to be unusually prolific. A considerable percentage of the moths of the first brood come from hibernating larvae of the previous autumn. Experiments were begun to learn whether codling moths could be attracted to colored lights, and various methods of control are being studied.

Work on the project concerning the utilization of feed by range steers was confined largely to a study of alfalfa hay. Range steers of various ages were fed exclusively on alfalfa hay for 120 days. Some of the animals showed almost a complete market finish at the end of that period, but for the most part they would be classified as high-grade feeders. The rate of daily gain per thousand pounds of live weight ranged from 0.9 to 3.1 for the different ages of animals, and the amount of feed consumed per thousand pounds of live weight for 1 pound of gain ranged from 18 to 24 pounds. No evidence was obtained that the digestibility of the ration was affected by the amount of feed consumed or by the stage of fattening in the experimental animals.

In an investigation of soil-moisture problems in arid soils it appeared that the wilting point for corn on such soils was near 7 per cent of moisture and that the hygroscopic moisture ranged from 1.1 to 5.1 per cent. The rate of penetration of moisture in uniform sandy-loam soil was determined as about 5 feet in 20 days. On soil planted with wheat a combined transpiration-evaporation-loss of 1,262 pounds for each pound of dry matter produced was noted. In attempts to determine the losses of moisture by evaporation from soils cultivated to different depths, it appeared that the lowest evaporation occurred when the soil is cultivated 4 inches deep. In general, evaporation from soils was found to be proportional to the amount of water in a few surface inches.

Interesting results were also obtained in tank experiments on the movement and changes of alkali salts. It appeared that three 6-inch irrigations in adobe soil would remove sodium chlorid beyond a depth at which it would influence the growth of most crops, while sodium sulphate was not carried down beyond a few inches by the same treatment. While 0.05 per cent of black alkali had been considered as toxic to wheat it was found that this amount at least in tank experiments acted as a stimulant and showed no toxic effect.

The attempt to determine the cause of the failure of potatoes to produce satisfactory tubers has led thus far only to negative results, but the work has given hints of a more promising direction in which to pursue investigation.

*Work with Hatch and other funds.*—With the support of Hatch and other funds a large variety of problems was investigated. A general survey was instituted to determine the extent and distribution of alkali in the State and to accumulate information regarding its toxicity, the possibilities of removing it by drainage, and crops which appear to be particularly resistant. The department of agronomy made a number of variety tests with cereals and nonsaccharine sorghums. An experiment was also begun to determine the best cultural methods for corn in New Mexico.

In the department of animal husbandry feeding experiments with dairy cows, pigs, and steers were carried on. The problem of feeding stock in New Mexico is considered as being properly subdivided into two problems of feeding in winter and in summer. A study was made therefore of the extent to which silage may be economically used to replace soiling crops or hay according to the season of the year. The place of dried-beet pulp in the summer and winter rations is also receiving attention. It was proved that the cost of pork production may be materially reduced by the use of alfalfa pasture. The largest returns from pigs were obtained when allowed to receive skim milk and a small amount of grain while having the freedom of an alfalfa pasture.

The biological department carried on several minor lines of work on insects and plant diseases. The chlorosis of foliage of orchard trees was corrected to some extent by spraying with a 1 per cent solution of ferrous sulphate. Of the various insecticides used in the control of the San José scale kerosene emulsion seemed to be the least effective, while whale-oil soap gave very satisfactory results, especially in cleaning the larger limbs of infested trees.

In order to compare the effect of the penetration of irrigation water to different depths, different amounts of water were applied to peach trees. In these experiments it was found that applications of only 3 inches of water are less satisfactory than applications of 4 or 5 inches, the differences being observed not only in the growth of the tree but in the amount and the quality of the fruit. Rather extensive experiments were planned and begun to determine the duty of water in growing alfalfa and for various field and fruit crops.

In a study of the resistance of peaches to frost it appeared that the blooming period was not the most susceptible stage of growth, but that the peach was least resistant when about the size of a pea. A temperature of  $26^{\circ}$  lasting only a short time did little injury to the opening bud, while a further fall of  $\frac{1}{2}^{\circ}$  of temperature proved quite disastrous. Whenever the killing temperature occurred late at night and remained below the danger point until sunrise the injury was in all cases very serious.

As a result of a number of experiments in applying fertilizers to peach trees it was noted that barnyard manure and sodium nitrate sometimes produced too much growth for the best results in fruit. The fruit was larger, but defective in color. Of various legumes used as cover crops in orchard experiments for winter planting, sweet peas gave the best results, proving to be more resistant to cold than most other legumes used for this purpose.

The publications received from this station during the year were as follows: Bulletins 86, Soil Moisture; 87, Trees and Shrubs of New Mexico; 88, Preliminary Tank Experiments on the Movement,

Changes in Composition, and Toxic Effect on Wheat of Certain Salts in Sandy Loam and Adobe Soils; 89, Hardiness of Fruit Buds and Flowers to Frost; and 90, Alfalfa Pasture for Pigs.

The income of the station during the past fiscal year was as follows:

|   |                 |
|---|-----------------|
| United States appropriation, Hatch Act-----               | \$14, 510. 15.  |
| United States appropriation, Adams Act-----               | 15, 000. 00     |
| Balance from United States appropriation, Hatch fund----- | 489. 85         |
| Individuals -----   | 200. 00         |
| Farm products -----                                       | 1, 351. 51      |
| Balance from previous year-----                           | 2, 490. 81      |
| <br>Total -----   | <br>34, 042. 32 |

The requests for help in technical and practical directions increased, and the present organization of the station gave evidence of being able to meet these requests more and more effectively.

#### NEW YORK.

Cornell University Agricultural Experiment Station, Ithaca.

W. A. STOCKING, JR., M. S. A., *Acting Director.*

During the year the affairs of the station were administered by an acting director; Dr. B. T. Galloway was appointed director, to assume his duties soon after the close of the fiscal year. The State legislature appropriated \$3,600 to be applied to salaries and maintenance for experimental work in plant breeding, of which Prof. R. A. Emerson assumed charge soon after the close of the year. A number of appointments were made during the year by way of strengthening the staff of the experiment station. A new poultry plant was constructed on the poultry farm, to be used mainly for experimental work. The capacity of this plant is approximately 1,200 fowls.

*Adams fund projects.*—The investigation of the habits, life history, and means of controlling the tarnished plant-bug were completed, and results published in bulletin form. The experiments show that it is doubtful whether injuries to peach nursery stock by this pest can be prevented by the use of deterrents or whether adult bugs can be killed by any of the usual contact insecticides. Mechanical means of catching the bugs also proved rather ineffective. The best method of preventing injury to nursery trees seemed to be found in excluding the adults by means of a wire screen fence or by inclosing the tips of the twigs in bags during the period when most injury is inflicted. The study of the life cycle and methods of control was also made in the case of *Aphis pomi*, *A. sorbi*, and *Cryptorhynchus lapathi*.

Work on the influence of soil moisture and temperature on the availability of plant nutrients in the soil was carried on in the green-

house, using wheat, oats, millet, and other crops. The percentage of moisture was varied. The effect of variations in moisture was shown principally on nitrates, which disappeared almost entirely at the saturation point. The amount of moisture made no apparent difference in the percentage of available potash and phosphoric acid. These tests were carried on in double series in pots in which plants were grown and on bare pots.

The investigation of the composition and concentration of soil water under different methods of soil treatment was conducted in concrete pits as heretofore and developed into a study of the relation of higher plants to the formation of nitrates. Corn appeared to stimulate the formation of nitrate in the early stages, but to retard it later. Bare plats produced more nitrogen than those on which grass was grown. Apparently there are both stimulating and depressing factors due to the plant, one dominating the other at different stages. The exact cause of this phenomenon was not determined. With all plants on which experiments were made the process of nitrification was apparently depressed as the plants approach maturity. At the close of the growing period the nitrates were greatly reduced in quantity under all crops, but to a greater extent than would be accounted for by the nitrogen removal by the crop.

In determining the conditions under which lime is removed from the soil the effect of different crops on the loss of lime and of potash fertilizers in drainage was studied. Experiments were conducted in large concrete tanks. A record was kept of the composition of each horizontal foot of soil in these tanks. Thus far the most striking result noted was the protective action of plants in conserving calcium and, to a less extent, other bases, as well as nitrogen.

Work in plant breeding was carried on actively. In the study of timothy 17 of the new varieties originating in these experiments have been under test for four years. The yield in the case of five of the best varieties is about 1 ton of hay larger than the yield from ordinary commercial seed. The effect of inbreeding of certain strains is under observation. Results were obtained which indicated that bud variation may occur to some extent in timothy. The study of mutations included work on timothy, root crops, clover, brome grass, and alfalfa. Moreover, in connection with the investigation of the correlation of characters in timothy, observations have been extended to wheat, daisy, alfalfa, clover, and oats for the purpose of making pure-line selections in these plants.

The inheritance of characters in hybrid oats and wheat was studied on the third generation of oats and the second generation of wheat. Rather definite results were secured in the segregation of characters. Some doubt was thrown on the persistence of variations produced

by environment in wheat and peas. No decided influence was noted from the injection of sulphates of copper, magnesium, calcium, or other chemicals into the ovaries of cereals. A study of bud variation within pure tuber lines in potatoes was continued upon a basis of single potato tubers of several varieties. Some of the variations appeared to be progressive.

From the study of variations in oats it appeared that variations due to environment operate to such an extent as to throw doubt upon the variety tests unless they are continued over several years. In all cases the yield of straw followed closely the yield of grain. A slight tendency was noted for heavy yielding varieties to have a larger seed. A high weight per bushel was found not necessarily to mean a high yielding capacity.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds considerable work was done by all of the departments of the station. The comparative effect of timothy and alfalfa upon the nitrogen balance of soil was investigated with the result that the soil under alfalfa appeared to nitrify more rapidly than that under timothy. Some data were also accumulated on the influence of fertility of the soil upon the process of nitrogen fixation.

The bacterial flora of some of the more productive and some of the less productive sections of the field was studied in order to gain evidence as to the correlations which occur between fertility of the soil and the bacterial flora. Except during the winter, the total number of bacteria proved to be higher in the more compact and less productive areas. No type of bacteria found frequently in one soil was entirely lacking in another. There seemed to be an intimate connection between the moisture content and the numbers of bacteria, except when the soil was frozen.

The soil survey was continued in Oneida, Chautauqua, and Clinton Counties. Experiments in top-dressing timothy and alfalfa showed that the application of fertilizers to timothy increased the productiveness of the soil for succeeding crops, particularly for corn and oats. Commercial fertilizers proved about equally effective with farm manure for this purpose.

The experiments carried on during the year in dairying involved the study of the distribution of water and salt in butter, the factors influencing the yield of Cheddar cheese, and the effect of changing the temperature of the milk, the speed of the separator, and the rate of inflow upon the effectiveness of the separator, and also a number of other minor investigations. A larger loss of fat in the whey took place when the curd was cut fine than when it was cut coarse. Coarse cutting also increased the yield of green and of cured cheese, as well as the moisture content of the cheese. Up to a certain point the in-

crease of rennet also increased the moisture content of the cheese and had the same effect as setting at a high temperature or cutting the curd while hard.

The use of dry sulphur as a germicide for the control of potato scab was thoroughly investigated. The results indicated that this method is not of commercial value. A comparison of dusting and spraying apple trees for the control of the apple scab and San José scale indicated that the dust method would not be effective against San José scale if applied during the dormant season. The use of finely ground sulphur as a fungicide element in a dust mixture gave encouraging results. Arsenate of lead in powdered form proved more effective than the same substance applied with water. The cost of material and the application of the dust mixture was slightly greater than spraying with liquid.

An investigation of apple scab incidentally indicated that the early infection takes place chiefly, if not entirely, from ascospores, and may appear during the first period of warm weather after the ascospores have matured. The period of incubation varies from 8 to 15 days and the earliest infections were found to occur on the lower side of the leaves. Applications of strong lime-sulphur wash during winter produced no difference in the amount of scab on the treated trees, but in many cases a single spraying after the blossoms fell gave excellent results.

The principal investigations in floriculture were concerned with roses, sweet peas, asters, phlox, gladioli, and peonies. An elaborate system of classification for the garden varieties of sweet peas was worked out and the results published in bulletin form.

Additional confirmation was obtained during the year of the importance of constitutional vigor in the breeding of poultry, and also of the importance of external characters, such as the time of molting, color of shanks, early production, etc., as indicating prolificacy. The selection of fowls for strong vitality, even though such selection be exercised but once, increases the productive power of a flock. One selection, however, was not sufficient to keep the flock permanently superior in egg yield. It appeared that the selection of mature pullets was of more importance than partly grown chickens, and that selection at the beginning of the second year was of equal importance with that of the first year.

In the department of farm management a continuation was made of the survey of Jefferson and Livingston Counties, of the study of successful farms found by the survey method, of the study of the cost of producing milk, of farm prices, and of methods of farm accounting. The relation of crop yields and prices and the future food supply was investigated from an economic standpoint. It ap-

peared that while much land now idle can be brought into tillage, thus considerably increasing the amount of production, there is little that can be done to increase production on present farm lands without involving increased cost. Careful plans were worked out for making agricultural surveys in such a manner as to obtain reliable information on the cost of production and the economics of agriculture.

The following publications were received from this station during the year: Bulletins 330, Respiration of Fruits and Growing Plant Tissues in Certain Gases, with Reference to Ventilation and Fruit Storage; 332, Oriental Pears and Their Hybrids; 333, Control of Two Elm-tree Pests; 334, A Study of Some Factors Influencing the Yield and the Moisture Content of Cheddar Cheese; 335, Scab Disease of Apples; 336, Distribution of Moisture and Salt in Butter; 337, The Babcock Test with Special Reference to Testing Cream; 338, An Examination of Some More Productive and Some Less Productive Sections of a Field; 339, Experiments Concerning the Top Dressing of Timothy and Alfalfa; 340, Experiments in the Dusting and Spraying of Apples; 341, Crop Yields and Prices, and Our Future Food Supply; 342, Sweet-pea Studies—IV, Classification of Garden Varieties of the Sweet Pea; 343, Oats for New York; and 344, Agricultural Surveys; Circulars 17, The Formation of Cow-testing Associations; 18, Milking Machines—Their Sterilization and Their efficiency in Producing Clean Milk; 19, Late Blight and Rot of Potatoes; 20, The Fire Blight Disease and Its Control in Nursery Stock; 21, The Yellow-leaf Disease of Cherry and Plum in Nursery Stock; and 22, Wholesale Prices of Apples and Receipts of Apples in New York City for Twenty Years; Memoirs 1, Some Relations of Certain Higher Plants to the Formation of Nitrates in Soils; and 2, The Action of Certain Nutrients and Nonnutrient Bases on Plant Growth—I, The Antitoxic Action of Certain Nutrient and Nonnutrient Bases with Respects to Plants, II, the Toxicity of Manganese and the Antidotal Relations Between This and Various Other Cations with Respect to Green Plants, III, Toxicity of Various Cations; and the Annual Report, 1913.

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|--|-------------|
| United States appropriation, Hatch Act | \$13,500.00 |
| United States appropriation, Adams Act | 13,500.00   |
| Total                                  | 27,000.00   |

The members of the station staff have hitherto been called upon for considerable extension work as well as teaching. With the relief now furnished from a number of these duties and interruptions of experimental work, the investigators will be able to confine themselves to research work of more fundamental importance than was previously possible.

## New York Agricultural Experiment Station, Geneva.

W. H. JORDAN, D. Sc., LL. D., *Director.*

The work of the station continued along established lines without essential change in policy and no important changes in the staff. The State legislature provided a fund of \$15,000 for conducting field and orchard investigations and studies of sanitary milk production. An appropriation of \$5,000 was also made for the investigation of hop diseases. In the furtherance of this work three hop yards, including about 12 acres, were leased near Cooperstown, N. Y. The station has the advantage of State printing without limitation as to the number or size of bulletins. The amount of published material was larger than during any previous year. A battery of tanks for soil work was installed; otherwise no noteworthy addition to the equipment of the station was made.

*Adams fund projects.*—Decided progress was made in the study of ash constituents and their effect and function in nutrition. Particular attention was given to an investigation of the phytinlike body in wheat bran. Evidence was obtained that this body is not phytin, but inosite-monophosphate, a new compound, different from inosite-hexophosphate, which the station found in corn, wheat, and cotton-seed meal, but not in wheat bran.

In continuing the study of the compounds in cheese particular attention was devoted to casein of milk. In this work five compounds of casein with lime and corresponding compounds with other bases were isolated, and data were obtained on the molecular weight of casein. It appeared that the percentage of phosphorus in casein had been estimated too high. It was actually only about 0.7 per cent. Pure preparations of some of the casein compounds were made for use in feeding infants, and notable results were obtained from these in cases of malnutrition. The station has a herd of goats, and has begun similar work with goat's milk in connection with infant feeding.

*Work with Hatch and other funds.*—The greater part of the research and experimental work of the station was carried on with the support of State, Hatch, and other funds. In studying the factors which influence the bacterial content of milk an experimental device was perfected for determining the number of bacteria which gain entrance to the milk from the air during the process of milking by machines. It was found that in order to arrive at reliable conclusions as to the source of bacteria in milk special attention must be given to each single dairy process by itself. The protection of milk pails from accidental contamination had a measurable effect in reducing the bacterial content of the milk, but the cleanliness of the interior of the stable within a fairly wide range had no noticeable

effect on the milk. Clipping the udder actually increased to a slight extent the bacteria in the milk. It was found possible without special effort to obtain milk with a smaller count than 1,000 bacteria per cubic centimeter.

In a comparison of the microscopic and plate methods of counting bacteria in milk evidence was obtained that the microscopic method is more accurate and that it indicates a much larger count in most samples than that obtained by the plate method. In some instances the count was 44 times as high. This was explained as meaning that clumps of bacteria were counted as units in the plate method. The microscopic method has also the decided advantage that the number of bacteria can be determined in a sample of milk in a few minutes. In an investigation of the cells derived from the udder in milk it was shown that these cells include leucocytes, epithelial cells, nuclei, or smaller fragments. The largest average number of cells occurred in colostrum, but an equally large percentage of cells occasionally occurs in milk at any time during the period of lactation. Marked daily variations in the number of cells were noted without apparent reason. The number of cells found in milk in these experiments ranged from 500,000 to 1,000,000 per cubic centimeter.

In the study of the soil flora an attempt is being made to isolate and classify the common bacteria which occur in the soil. The most common ones will be isolated and the function of each one determined. This appeared to be more satisfactory than an attempt to study the nitrifying and denitrifying powers of the soils as a whole, for the reason that in each soil there is a mixed lot of bacteria. Repeated examination of frozen soils indicated that there is an actual multiplication of bacteria in soils after being frozen for two or three weeks.

The entomological work included thorough studies of the life history and habits of several injurious insects, and miscellaneous notes on a large variety of insect pests. *Lygus invitus* was found to cause injury to pears, resulting in the cracking open of the skin. The pest appeared also to attack clusters of grape blossoms. The spraying mixture which gave the best results contained three-fourths of a pound of tobacco extract (40 per cent nicotin) to 100 gallons of water, to which 3 pounds of dissolved soap were added. An application of this mixture just after the blossoms fell gave satisfactory results. The cabbage maggot was shown to be the principal handicap in the production of early cabbage and cauliflower.

Tests of carbolic-acid emulsion on the roots of cabbage and cauliflower showed that this is fatal to the eggs and young larvæ, but that it causes some injury to the plants. The use of tar pads adjusted so as to prevent the early cabbage maggot from placing its eggs around the roots of plants gave good results, at a cost of about \$1.40 per thousand plants.

Many failures were reported in attempts to control the pear psylla. The station therefore made a study of the susceptibility of hibernating pear psylla adults and their eggs to insecticides. It was found that the best means of destroying this pest is spraying with a tobacco extract during a period of warm weather, preferably in November or December or early in April. A study was also made of the habits, life history, and means of controlling the common tree crickets, which injure orchard and garden crops. *Phylloscelis atra*, commonly called the cranberry toad-bug, caused serious injury to the cranberry growers on Long Island. The cranberry seemed to be the only host plant of this pest. It was found that there is but one brood of the insect annually. Flooding of the cranberry bogs proved to be the most satisfactory method of controlling the insect.

The horticultural department carried on a large variety of investigations. As a result of 10 years' observations in comparing tillage and sod mulch in apple orchards it was found that in one orchard the average yield was 47 bushels per acre in favor of the tilled plats; that the leaves of tilled trees came out three or four days earlier and remained on the trees a few days longer; that the cost of growing and harvesting the apples was \$31.75 less on the sod than on the tilled plats; but that the yield was so much greater on the tilled plats as to give a net difference of \$66 in favor of tillage. Sod was found to lower the water supply, diminish some of the plant-food elements, reduce the humus, lower the temperature, and to affect deleteriously the bacterial flora.

In another orchard with different slopes and physical conditions evidence was obtained that the sod mulching for apple trees may be attempted advantageously for orchards on steep hillsides or on land covered with rocks. The soils must be deep and retentive of moisture, however, otherwise the method will prove unsatisfactory.

On account of the decline in the yield of grapes in the Chautauqua grape belt, fertilizer experiments were undertaken to determine whether the yield of grapes could be benefited thereby. Nitrogenous fertilizers had a marked beneficial effect upon the yield and quality of fruit, while lime exercised no appreciable effect and phosphorus and potassium had so small an influence as to be unprofitable. It became evident during these experiments that the fertilization of vineyards is so involved with other factors that reliable conclusions can only be drawn after several years of work. Nitrogen was apparently the element most frequently needed. A strict financial account was kept of the operations of an orchard for a period of 10 years. During this time an average price of \$2.60 per barrel was obtained for firsts and seconds, and 72 cents for cider apples. Deducting the cost of production, a net profit of \$1.31 per barrel for firsts and seconds was obtained or \$103.49 profit per acre.

In addition to these lines of work, the horticultural department carried on variety tests with various fruits, breeding of grapes with reference to the possible transmission of hardiness and disease resistance, experiments designed to develop seedless grapes, studies of apple seedlings, attempts to determine whether Duke cherries are hybrids, the study of mildew resistance of gooseberry hybrids, and numerous experiments in budding, grafting, pruning, and the use of dynamite in orchards. From the miscellaneous new fruits tested at the station, descriptions and the recommendations were given concerning some of the most promising varieties.

Many important findings were made by the station in the study of plant diseases. It was shown that *Phytophthora infestans* apparently does not persist in the soil. Potato blight and rot were successfully controlled by spraying, and while spraying occasionally proved unprofitable it was shown to be highly profitable through a series of years. Fumigation of potatoes with formaldehyde gas caused considerable injury in the form of sunken brown spots surrounding the eyes. The cause of this injury was apparently found in the use of too small quantities of potatoes per cubic foot of space and in the high relative humidity of the fumigating house. The process of fumigation was found to be safe and efficient for potato scab when 3 pints of formaldehyde and 23 ounces of permanganate of potash were used on 167 bushels of potatoes in 1,000 cubic feet of space. The standard methods of treating seed potatoes for scab were tested with reference to *Rhizoctonia* disease of potatoes. Formaldehyde was found ineffective for this disease either as a gas or in solution. The standard corrosive sublimate treatment, on the other hand, proved thoroughly satisfactory.

Currant felt rust and white pine blister rust were found due to the same fungus, *Cronartium ribicola*. Numerous experiments were undertaken to determine whether this fungus can live over winter on the currant. The evidence obtained from experiments with 500 plants indicated rather clearly that the fungus rarely passes the winter on currant vines. It is therefore considered unnecessary to quarantine currants affected with felt rust.

As a result of an extensive series of potato-spraying experiments on 66 fields, in 47 of which spraying was done by the station on plats alongside of unsprayed plats, an average increased yield of 17 bushels per acre was obtained. This increase was believed to be due to the partial control of tip-burn and of Colorado potato beetles.

From the examination of over a thousand seed samples which were received during the year about 17 per cent were found to contain an excess of foul and foreign seed over that permitted by State law. The most frequent defective samples were found in lawn grass, grass-seed mixtures, and clovers.

In the field of agronomy an investigation is being made of the possibility of successful alfalfa culture on the poorer hill lands of southern New York. Attention was also given to the profitable limit of the cultivation of soil in corn growing, experiments with fertilizers, lime, and soil management with potatoes, tests of soy-bean varieties, rotation experiments, a study of the influence of minor mineral nutrients on plant growth, and a comparison of early and late planting for potatoes.

In the line of animal industry, experiments are being conducted on the nutrition of milch goats, the economy of the production of goat milk, breeding experiments with poultry with reference to the transmission of egg-laying capacity, and feeding experiments with fowls.

The publications received from this station during the year were as follows: Bulletins 363 (popular edition), The Price Control Factor in the Pure Milk Problem; 364 (with popular edition), New or Noteworthy Fruits; 365 (with popular edition), The Effect of Certain Dairy Operations upon the Germ Content of Milk; 366, Inspection of Feeding Stuffs; 367 (with popular edition), The Persistence of the Potato Late-Blight Fungus in the Soil; 368 (with popular edition), The False Tarnished Plant Bug as a Pear Pest; 369 (with popular edition), The Injurious Effect of Formaldehyde Gas on Potato Tubers; 370 (with popular edition), The Efficiency of Formaldehyde in the Treatment of Seed Potatoes for Rhizoctonia; 371, Report of Analyses of Samples of Commercial Fertilizers Collected by the Commissioner of Agriculture during 1913; 372, Director's Report for 1913; 373, A Comparison of the Microscopical Method and the Plate Method of Counting Bacteria in Milk; 374 (with popular edition), Does *Cronartium ribicola* Over-winter on the Currant?; 375 (with popular edition), Tillage and Sod Mulch in the Hitchings Orchard; 376, Ten Years' Profits from an Apple Orchard; 377, The Cranberry Toadbug; 378 (with popular edition), Seed Tests Made at the Station during 1913; 379 (with popular edition), Potato Spraying Experiments at Rush in 1913; 380, Cells in Milk Derived from the Udder; 381, A Test of Commercial Fertilizers for Grapes; 382, The Cabbage Maggot in Relation to the Growing of Early Cabbage; 383, A Comparison of Tillage and Sod Mulch in an Apple Orchard; 384, Analyses of Materials Sold as Insecticides and Fungicides; 385, New or Noteworthy Fruits, II; and 387, Susceptibility to Spraying Mixtures of Hibernating Pear Psylla Adults and Their Eggs; Technical Bulletins 30, The Influence of Temperature and Moisture in Fumigation; and 31, The Action of Rennin on Casein; Circulars 25, Apple Insects; 26, The Use of Commercial Fertilizers; and 27, Ground Limestone for Soil Improvement; and the Annual Report, 1912.

The income of the station during the past fiscal year was as follows:

|  |            |
|--|------------|
| United States appropriation, Hatch Act-----                        | \$1,500.00 |
| United States appropriation, Adams Act-----                        | 1,500.00   |
| State appropriation, including balance from previous<br>year ----- | 142,962.83 |
| Total -----  | 145,962.83 |

The work of the New York State station continues to rank as high-grade research in several lines. This research is of fundamental importance. While the energies of the station are primarily directed toward the advancement of agricultural research, the practical problems of the agriculture of the State are not neglected.

#### NORTH CAROLINA.

North Carolina Agricultural Experiment Station, *Raleigh*.

B. W. KILGORE, M. S., *Director*.

Considerable readjustment took place during the year in bringing about a more complete organic connection between the two stations of the State. The division of markets was created for the purpose of making an investigation of marketing conditions in the State and of possible markets outside the State, especially in large cities, for the surplus farm and truck crops of North Carolina. Only unimportant changes occurred in the staff. Improvements were made on buildings upon the branch stations to the value of about \$7,000.

*Adams fund projects.*—The relationship of the geological structure and the chemistry of soils to their productivity and fertilizer requirements was studied on four types of soil in four different localities. Particular attention was given to the plant-food requirements of small grains, cotton, corn, and legumes on these soils. Bacteriological examination of the soils was also made in connection with this work.

Corn was badly injured during the year by winds, which thus prevented to some extent the study of the cause of suckering of corn. Evidence was obtained, however, that the more fertile the soil the greater the number of suckers. The results obtained from removing the suckers indicated that this decreases the yield of both corn and stover, contrary to the usually accepted opinion. Some progress was made on the study of the changes which occur in the character of cotton when removed from one locality to another. The seed used in this experiment was obtained from the Mississippi station.

The study of the life history of the corn billbug was finished. It was found that this pest destroys as much as 98 per cent of the corn in some localities. Progress was also made on the gloomy scale.

In a further investigation of the toxicity of cottonseed meal satisfactory results were obtained in preventing the poisonous effect of the meal by feeding daily about one-third ounce of iron chlorid or of copperas per hundred pounds of live weight of hogs. Ashes fed ad libitum also had a somewhat beneficial effect, but were not as efficient as iron chlorid or copperas. Pigs fed in inclosed pens from May 28 to November 4 remained in perfect condition, although they received 1 pound of cottonseed meal daily per hundred pounds live weight. Analyses indicated that the blood of hogs which received iron chlorid showed a slightly larger than normal percentage of iron. Weekly examinations were made of the blood, during which the ratio of red and white corpuscles was determined and the percentage of hemoglobin.

The work on the transmission of characters in hybrids of *Rotundifolia* grapes brought out some rather definite and important facts. It was found that colors in this group of grapes behaved as Mendelian characters, and that by making the proper combinations seedlings of either white, red, or black colors can be produced at will. It was shown also that the white color is recessive to all dark colors, and that conversely red or black is dominant over white, black being dominant over red. While the seedlings of *Rotundifolia* grapes vary considerably in size of berry and other characters, the indication was that by proper combination of parent vines highly desirable seedlings may be produced. In this work about an acre of land and 1,000 seedlings were used.

In pursuing the investigation of apple diseases attention was given to a root disease, the cause of which is unknown. A fungus has been isolated which may possibly prove to be the cause of the trouble. Data were also collected on the principal apple diseases of the State. Difficulty was experienced in devising the proper cultural methods for the fungus cause of lettuce drop. Work was also carried on with the sclerotia disease of lettuce that appeared to be the same as the sclerotia disease of clover. The yellowsides disease of cabbage and related plants received further attention. Some strains of cabbage received from Wisconsin seemed to be quite resistant to the disease. The trouble was found to be most disastrous in gardens and during hot weather.

The results obtained in the study of nitrification of soils were extremely variable. It seemed almost impossible to secure satisfactory samples which really represented the average bacterial condition of the locality in question. It was suggested that the activity of organism might be subject to local variations at different times. Lime exercised a marked effect on yield without bringing about a correlation between treatment and nitrification.

*Work with Hatch and other funds.*—The work carried on under Hatch and other funds involved a number of lines of study. In carrying on the soil survey the field results indicate a rather close relation between the chemical and mineralogical composition of the soil and the fertilizer requirements for different plants on these soils. The phosphoric-acid content of North Carolina soils proved to be low. Lime in the soils of the Coastal Plains was for the most part less available for crops than that found in the higher regions of the State. In the mineralogical composition of these soils little difference was observed between soil and subsoil.

A few tests were made to determine the relative cost of raising young chickens by natural and artificial methods of incubation and by brooders heated with oil and coal. An attempt is in progress to breed a strain of tobacco resistant to wilt. By means of seed selection an effort is being made to secure a strain of cotton relatively resistant to anthracnose. Attention is also given to the chestnut-bark disease, potato spraying, the economic phases of beef, mutton, and pork production, particularly with cottonseed meal as an important element of the ration.

A study of cotton varieties in different parts of the State showed a range of yield between 434 and 1,045 pounds of seed cotton for short-staple varieties and between 479 and 927 for long-staple varieties. The best method of working over seedling pecan trees was found to be by means of patch budding. Considerable attention was also given by the station to the organization of cooperative associations among farmers and to the practical study of the market conditions for truck and fruit crops in the State.

Experiments were conducted to determine the proper amount of cottonseed meal to supplement a cattle ration containing cottonseed hulls and silage. The effect of variations in this ration on the marbling and firmness of the meat was also studied. The economic phases of keeping sheep and producing spring lambs was investigated, and data were also collected on the effect of rations upon the quality of mutton. A beginning was made on a study of the effects of cottonseed meal in different quantities upon the firmness and character of lard in a series of feeding tests with hogs. In cooperation with this department experiments are being carried on to determine the value of mountain pastures and to study methods of wintering cattle and fattening cattle in summer on pasture with supplementary feed, including cottonseed meal.

The publications received from this station during the year were as follows: Bulletins 224, Top-working Seedling Pecan Trees; 225, How Shall Farmers Organize?; 226, Report of Variety Tests of Cotton for 1913, and a Summary of Results for the Past Eleven Years; Circulars 1, Silo Facts; 2 (rev.), Beef Cattle and Sheep

Barns; 3, Method of Improving Cotton by Seed Selection; 4, Curing Meat on the Farm; 5, A Remedy for Cottonseed Meal Poisoning; 6, Composition and Fertilizing Value of Farm Crops and Other Farm Materials; 7, The Premier Clover for North Carolina Farmers; 8, Effects of Applying Commercial Fertilizers to Corn and Cotton by Different Methods; 9, Grass Mixtures for North Carolina Pastures; 10, Hairy Vetch; 11, Source, Availability, and Suitability of Different Forms of Plant Food Constituents to Different Crops; 12, Effects of Different Fertilizing Materials Upon the Maturity of Cotton; 13, Long Staple Cotton in North Carolina; 14, Buying Cotton Seed for Planting; and 15, Farmers' Clubs, Their Organization and Work.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----           | \$15,000.00 |
| United States appropriation, Adams Act-----           | 15,000.00   |
| Farm products, including balance from previous year-- | 13,244.00   |
| Miscellaneous-----                                    | 4,950.00    |
| Total -----   | 48,194.00   |

The North Carolina station carries on a large amount of work of much interest to the farmers of the State. The separation of extension work from the station will relieve the station of numerous burdens which it has had to carry and thereby tend to make its experimental work of still greater value.

#### NORTH DAKOTA.

*North Dakota Agricultural Experiment Station, Agricultural College.*

T. P. COOPER, B. S. A., *Director.*

The station underwent considerable reorganization during the year. Thomas P. Cooper, formerly secretary Better Farming Association of North Dakota, was appointed director, succeeding J. H. Worst, president of the college, and a decided change was put into operation in carrying on the Adams fund projects. The assignments of individual men to particular problems were made more definite. The State appropriations continued essentially the same as for the past year. Demonstration farms were generously recognized by the State legislature. Five of these substations were maintained during the year. The erection of a new dairy building provided greater conveniences for experimental work in dairying. A dairy barn was also built for the proper housing of the dairy cattle.

*Adams fund projects.*—The veterinary department continued its work on swamp fever. The phenomenon of complement fixation was thoroughly studied again, using different antigens. This work is carried on for the purpose of securing reliable means of diagnosing

the disease. Since, however, antigens are always present, it is believed that the method will not prove to be entirely satisfactory. One horse, which has been under observation for five years and has remained in good condition, still has virulent blood. The possibility of the disease being carried by insects, particularly mosquitoes, is being considered. Various alleged cures for the disease were tested without satisfactory results. The disease has been shown to be identical with that which occurs in Texas and Alberta, Canada.

In the study of hog cholera a determined effort was made to learn the cause of many failures to secure a good serum. This involved much field and laboratory work, and the conclusion was reached that the method of complement fixation will give an indication of the value of the serum and of the degree of immunity produced.

Work progressed satisfactorily on the study of disease resistance and immunity in crops. The differences in the enzymes in immune and less-resistant strains of flax were investigated and slight differences were definitely determined. The work will ultimately be extended to include other plants. In a study of the ammonifying power of soils in the wheat and flax plats and in the virgin soils an attempt is being made to determine the true relations of different groups of bacteria in these soils. An effort is also being put forth for standardizing the efficiency of nitrification, ammonification, and nitrogen fixation.

The study of the relation of soil fungi to cropping methods was continued actively and a great mass of information was accumulated. It was definitely shown that constant cultivation of wheat on the same lands brings about so-called wheat sickness, no matter how fertile the soil may be. This constant cropping seemed not to exhaust the fertility of the soil. The diminution of yield appeared to be due to the gradual accumulation of fungi which live upon the dead plant substances and upon the roots of the living plants, attacking the roots and ultimately penetrating to the leaves, stems, and developing grain. Rather convincing evidence was obtained of the connection of these fungi with the gradual falling off in yield. The problem of wheat-sick soils is therefore considered not primarily a matter of soil fertility but a matter of soil sanitation, which may be largely corrected by proper methods of soil tillage and rotation.

In continuation of the study of the organic matter of soils in relation to fertility about 200 samples of soils were collected, including soils containing manure and rotting straw. Comparative nitrification determinations are being made on these different materials, together with tests of the fertility of the different soils as shown by pot cultures.

A study was made of 24 samples of pure Ghirka wheats to determine their relative value from baking and milling standpoints. In

an investigation of the milling and baking properties of wheat particular attention was given to Marquis, Bluestem, and Fife wheats. The Marquis wheat gave promising results, which indicate that the strain will continue to be satisfactory if propagated from home-grown seed. Under some conditions, however, the standard of milling properties appeared not to be maintained, and evidence was obtained that not all parts of the State are equally suited to growing this wheat for seed purposes.

*Work with Hatch and other funds.*—The usual lines of study were carried on under the support of Hatch and other funds. A thorough investigation was made of avian tuberculosis. Apparently this disease appeared first in the State in 1907. Ulcerations of the intestines were found to be comparatively rare in cases of the disease, the liver being the organ most commonly involved. A number of experiments were made in testing the intracutaneous method of using tuberculin for the determination of tuberculosis in fowls. The results were satisfactory. The wattles and comb proved to be the best parts in which to make the test. Reactions were clear and pronounced within 48 hours after injection. A small State appropriation made it possible for the station to prepare and distribute hog-cholera serum to the farmers of the State.

In the chemical department of the station a large number of miscellaneous analyses were made as heretofore, and various other lines of study were carried on, including field tests with fertilizers, examination of stock foods and insecticides, the occurrence of prussic acid in flax, and the study of the fertilizer constituents and feeding value of flax. It was found that flax contains pound for pound more plant food than the ordinary grain crops, and that flax straw and other coarse by-products of the flax plant are richer in protein than other straws, occupying a position between grain straws and legume hays. These materials proved to be satisfactory feeding stuffs. It is recommended, however, that only small quantities of flax straw be fed to stock since hydrocyanic acid may occur in it in sufficient quantities to be poisonous.

In a study of the effect of bran extracts on the baking qualities of flour it was found that in general the acid extract of bran produced larger loaves of bread of a better color and texture than the check loaf. As a rule, the higher the percentage of gluten in flour the more marked was the improvement produced by the use of acid extract. The larger loaves of bread were found to contain less phosphorus than the smaller loaves. In addition to other lines of work the chemical department made numerous examinations of water, oil, paint, varnish, and other materials as heretofore.

Experiments in which the departments of agronomy and animal husbandry cooperated were carried on in testing cultural methods for

various field crops, rotation systems, breeding experiments with wheat, oats, barley, flax, and corn. A series of experiments was also begun to secure information on the yield, quality, resistance to disease, and other factors in a number of varieties of potatoes. Attention was given to Grimm alfalfa in connection with experiments in breeding and inoculation of varieties of alfalfa and clover. Soil survey work was continued, the survey being completed for two counties. The economy of hogging-off corn was also tested with favorable results.

Among the miscellaneous lines of work of the station mention should also be made of a study of a general cropping system for flax, the use of windmills for electric lighting and power, and the study of the cost of producing farm crops, particularly wheat, oats, peas, corn, barley, and clover.

The following publications were received from this station during the year: Bulletins 103, Cropping to Flax on New Lands of Semiarid Land Areas; 105, Windmill Electric Lighting and Power; 106, The Fertility Constituents in Flax, An Investigation of the Feeding Value of Flax Material as Determined by Chemical Analysis, A further Study of the Distribution of Prussic Acid in the Flax Plant, The Influence of Bran Extracts on the Baking Qualities of Flour, the Phosphorus Content of Wheat and of Wheat Flour, and Its Relation to the Baking Qualities of the Flour; 107, Wheat: Soil Troubles and Seed Deterioration, Causes of Soil Sickness in Wheat Lands, Possible Methods of Control, Cropping Methods with Wheat; Special Bulletins Food Department, Volume 2, Numbers 12-22; Special Bulletins Food Department, Volume 3, Numbers 1, 2; Special Seed Bulletin 2, The Seed Control Act; Annual Report, 1911, parts 1 and 2; Annual Report, 1912, parts 1, 2, and 3.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act                       | \$15,000.00 |
| United States appropriation, Adams Act                       | 15,000.00   |
| State appropriation, including balance from previous<br>year | 16,468.81   |
| Miscellaneous, including balance from previous year          | 12,209.17   |
| Total  | 58,677.98   |

The investigational work of the North Dakota station is organized on a better basis than ever before, and in addition to bulletins and other means of publicity, the demonstration farm work, in cooperation with 24 farmers in different parts of the State, gave the station abundant opportunity to carry its practical results to the farmer.

## OHIO.

Ohio Agricultural Experiment Station, Wooster.

C. E. THORNE, M. S. A., *Director.*

The operations of the Ohio station progressed in a satisfactory manner along all lines of investigational and practical work. An addition to the station building was completed at a cost of about \$40,000. The equipment of the printing plant was also increased. The station creamery was destroyed by fire, but plans for a new plant were prepared and an appropriation for a new building was secured. A large shed for cattle feeding was built during the year. Tracts of land, representing the truck soils and hill farming soils in Marietta, were bought for a county experiment farm. All lines of work which the station has in hand were adequately provided for by State appropriations to supplement the Federal funds.

*Adams fund projects.*—Breeding and selection experiments for the purpose of fixing desirable properties in plants were continued, attention being given chiefly to wheat. As a result of five years' work, little encouragement was obtained for the possibility of securing a variation that could be fixed, either in the high or low protein or weight of grain. The length of the head proved to be apparently not a hereditary character. Attempts to fix a tendency to produce large or small kernels gave variable but, for the most part, negative results. A long-continued effort to increase the protein content of wheat by selection yielded no encouragement for such work. Similar studies with corn were made to include a large number of factors. Incidentally it was found that seed corn stored in racks gives a better yield, by  $7\frac{1}{4}$  bushels per acre, than the same corn stored in the center of a crib.

The investigation of the rôle of lime and phosphorus in soils and of the bacteriology of soils proceeded actively and yielded a number of interesting results. It appeared that the soils containing no calcium carbonate have larger amounts of total calcium and magnesium than have soils overlying sandstone and shales. Aside from their phosphorus content and amount of organic matter, the chief distinction between the surface soil and subsoil is found in their difference in texture. The average results of analyses of a large number of calcareous and noncalcareous soils showed that soils containing calcium carbonate have a larger supply of total phosphorus than noncalcareous soils. The soils classed as black clay loam contained the largest amount of total phosphorus. An effort was made to devise a method for more easily extracting the nitric nitrogen from organic nitrogen and for improving the analytical methods necessary in the study of nitrogen in soil. The nitrification studies were used as an index to the bacterial flora of the soil.

Important contributions were made to a study of the rôle of phosphorus and other mineral elements in animal nutrition. Additional evidence was obtained of the unsatisfactory character of corn, wheat middlings, linseed-oil meal, soy beans, and wheat bran as sources of lime for growing pigs. Pigs stored up in the body nine or ten times as much lime from rations containing milk and meat meal as from the best ration of grain. These results are considered as emphasizing the importance of pasture, forage crops, and dry roughage, especially of leguminous plants, as sources of mineral nutriment for growing animals. The important deficiencies of corn are considered as being found in calcium, phosphorus, and nitrogen. No pronounced success was had in establishing important specific differences in the effects of various forms of organic phosphorus.

*Work with Hatch and other funds.*—The Hatch fund and liberal State appropriations enabled the station to carry on a large amount of experimental and practical work. General fertility studies were prosecuted on a tract of 200 acres adjoining the station farm. On this tract a series of experiments has been instituted to compare the efficiency of the same amount of fertilizer elements from artificial fertilizers and manure, and also to determine which crops of the rotation should be fertilized and which manured. The proper place in the rotation to use lime is also being investigated. In experiments in oat culture, the results generally favor early sowing and the use of 9 pecks of seed per acre. On one of the demonstration farms experiments which have been carried on continuously since 1895 give clear evidence that phosphorus in any form will produce a profitable increase of yield on this soil. A comparison of home-mixed and factory-mixed fertilizers was decided in favor of home mixing.

Numerous experiments were conducted on the various substations in soil fertility, crop rotation, and cultural methods applicable to various kinds of grasses, roots, and miscellaneous forage crops. At the usual rate of wages for man hire and horse hire the total cost of producing an acre of corn was found to range from \$9.62 to \$16.72 in various parts of the State. The labor cost of harvesting corn proved to be more than one-third of the total labor cost of the crop.

Some attention was given to a study of the possible relation of insects in transmitting fire blight in orchards, and also to a study of grasshoppers, mosquitoes, forest insects, scale insects, the woolly aphid, the onion maggot, etc. Further work was done in determining the appearance of the different broods of the periodical cicada. A detailed study was also made of the life history and habits of the orchard bark beetles and pinhole borers.

Along the line of botany and plant pathology further studies were made on Ohio weeds and poisonous plants. Much information was

collected on the distribution and importance of various orchard diseases, particularly fire blight of pears and quinces, and also of the diseases of clover, alfalfa, onions, potatoes, and chestnuts. Progress was made on the plant disease survey of the State. In the tobacco-breeding work nine varieties of Ohio tobaccos have been selected and given out to representative growers. These tobaccos show an increase in yield of from 25 to 60 per cent.

A study of the cob rot of corn failed to discover the presence of *Coniosporium gecevi* in the living corn plant. The organism apparently develops and acts as an obligate saprophyte, and is therefore not considered the cause of the disease. It has an economic significance, however, in that it destroys cob tissue.

In addition to the Adams fund work, the chemical department made numerous analyses of wheat from the county farm and carried on some experiments in determining its value for flour in connection with the milling and baking laboratory equipped for that purpose. A study was also made of nitrate formation in peat soils. It was found that the formation of nitrate was about the same on lime and acid peat soils, being equivalent to about 1,000 pounds of nitrate of soda per acre. Fertilizer experiments were carried on with vegetables, and the other horticultural work of the station included cold-storage investigations with apples. A further test was made of the cultural value of mulch in orchards.

A study of the economics of poultry raising showed that the average cost of producing eggs on different rations varied from 7.62 to 10.77 cents per dozen. Feeding experiments were carried on with capons and studies were made of the fertility of eggs and the factors which affect this property. The various substitutes which may be recommended for corn in fattening hogs were found to depend largely upon the market supply and prices of these feeds. Oats proved less valuable than corn, while hominy feed and tankage yielded somewhat better results than did corn and tankage. Wheat in combination with tankage was shown to be no more efficient than corn.

Experiments in milk production showed that alfalfa, as well as soy beans, may economically be used to replace much of the nitrogenous concentrates. The extensive use of milling by-products was found unnecessary where legumes could be made to thrive well. A thorough study was made of the economics of producing winter lambs. In these experiments it was found that lambs born in July and August and maintained on clover pasture and a small amount of grain until November 25, and then fed in the barn, were produced at a smaller cost for feed than were lambs born in the fall and raised in the barn during the winter.

In the sheep work of the station individual records are being kept on the number of ewes and their offspring, and some breeding work is in progress, especially with reference to wool production. In-

formation was also accumulated on parasites affecting Ohio live stock, especially stomach worms in sheep, worms in hogs, and ox warble fly.

A preliminary oil survey of the whole State has been completed, and it is now proposed to cover the whole State with a detailed survey, partly in cooperation with the Bureau of Soils of this department. A great amount of interest has been awakened in forestry and forest planting as a result of station work along this line.

The following publications were received from this station during the year: Bulletins 249, Thirty-first Annual Report, 1912; 253, Insect Pests of the Household; 254, Fifth Annual Report of Forest Conditions in Ohio; 255, Mineral and Organic Analyses of Foods: New Methods for the Determination of Sodium and Crude Fiber; 260, Experiments with Fertilizers, Manure, Lime, and Floats; 261, Soil Investigations: Composition of Calcareous and Noncalcareous Soils (With Special Reference to Phosphorus Supply); 262, Experiments with Poultry; 263, Thirty-second Annual Report, 1913—Press Bulletins—Index; 269, Forage Crops: Annual Grasses and Roots; 271, A Chemical Study of the Nutrition of Swine; 272, The Hamilton County Experiment Farm: Second Annual Report, for the Year 1913; 273, The Paulding County Experiment Farm: Third Annual Report, for 1913; 274, The Miami County Experiment Farm: Third Annual Report, for 1913; Circulars 134, The Care of Cream; 135, Building Up the Dairy Herds of Ohio; 136, Care of the Dairy Herd; 137, Grasshoppers; 138, Increasing Crop Yields in Ohio; 139, The County Experiment Farm Law; 140, Orchard Bark Beetles and Pin Hole Borers; 142, The Periodical Cicada or Seventeen-year Locust; 143, The San José Scale, the Oyster Shell Bark Louse, and the Scurfy Bark Louse; 144, Plans and Summary Tables of the Experiments at the Central Farm, Wooster, and the Northeastern Test Farm, Strongsville, on the Maintenance of Soil Fertility Arranged for Reference in the Field; 145, The County Experiment Farm: Its Function, Selection, and Management; Wood-Using Industries, 1912.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act-----           | \$15,000.00 |
| United States appropriation, Adams Act-----           | 15,000.00   |
| State appropriation, including balance from previous  |             |
| year -----  | 419,488.54  |
| Farm products, including balance from previous year-- | 21,016.01   |
| Miscellaneous-----                                    | 10,914.27   |
| Total-----  | 481,418.82  |

The Ohio station is adequately meeting the important demands placed upon it by the agricultural interests of the State. Its work along the line of soil fertility and the mineral nutrition of animals is of particular importance.

## OKLAHOMA.

Oklahoma Agricultural Experiment Station, Stillwater.

L. L. LEWIS, M. S., D. V. M., *Acting Director.*

The work and organization of the Oklahoma station were seriously interfered with during the greater part of the year. Drastic action toward the station and its employees culminated in the summary removal of the director, James A. Wilson, without notice, July 1, 1913. In August the board of agriculture, to whom the management of the college is committed, was recalled by popular vote, following which the legality of the action was tested in the courts, restraining orders were issued against the new board appointed by the governor, and the station was temporarily deprived of any governing body. The legal controversy, which ultimately placed the affairs in the hands of the new board, was not settled until the following May. In the meantime the advances of the Federal funds were withheld for a period of nine months.

After the legal status of the new board had been determined and it had given assurance of its purpose to deal considerately with the station and its men, and to place the station on an efficient administrative basis which would secure proper use and safeguarding of the Federal funds, such portions of the funds were restored as were found warranted by the work carried on during the year and the expenses incurred. For the three quarters this amounted to \$3,899.08 from the Hatch fund and \$4,767.91 from the Adams fund.

Despite the unfavorable conditions and the fact that the station lost many of its men, a fair amount of investigation was continued along several lines, and the results secured in the past were preserved. Funds were advanced to the station from college and other sources. A poultry plant, for the use of both the college and the station, was established.

*Adams fund projects.*—The work on breeding corn and sorghums for the purpose of securing drought resistance was conducted essentially as a single problem. The moisture requirements of different sorghums were compared with corn and other plants in the greenhouse. Several varieties of sorghums were grown in the field for selection to secure greater drought resistance and the possibility of securing such qualities as early maturity, low stature, and shortness of internodes. Data were also accumulated on the wilting point of various soils for sorghums.

In the investigation of the chemical constituents of grain sorghums particular attention was given to Kafir corn and feterita, in which the physical constants were determined for various fats and rough separations made into saturated and unsaturated, saponifiable and unsaponifiable, volatile and nonvolatile acids. The starches of

all the grain sorghums were separated for further study, and some work was done on the proteids of sorghums. Thoroughly dried seed of feterita was ground in a mill and prepared in the form of a fine flour, which had a brownish color and a pleasant aroma. The flavor of baked products from this flour was found to be sweeter than similar articles prepared from Kafir-corn flour. A further study was made of prussic-acid poisoning from Kafir corn. A colorimeter test was devised for recognizing this poison, which was found present at all stages and times, but particularly at times of drought and frost.

Two new crosses were made in the investigation of sheep breeding, the Shropshire on the Dorset-Merino, and the Shropshire-Dorset upon the Dorset. The chief idea in this experiment has been to secure a combination of desirable characters, but careful records have been kept of all the crosses. The apiary was enlarged and a new Carniolan queen was obtained for use in bee breeding.

In studying the effect of cottonseed meal on breeding animals it was found that within reasonable limits cottonseed meal had no effect on the fertility of poultry and hogs so long as the animals remained in good health. Work was continued on the artificial impregnation of chickens. It was found that the male reproductive cells of fowls remained active two or three times as long at a temperature of 34° F. as at the body temperature. It appeared, however, that under natural conditions the reproductive cells remain active for 14 days or longer.

The investigation of soil bacteriology involved a study of two plats which have been in wheat continuously since 1892. Composite samples were taken and the ammonifying and nitrifying power determined. The plat which received barnyard manure showed a higher power of ammonification and nitrification as well as a higher bacterial count. Pot cultures were carried on for the purpose of checking these results.

An apparently important discovery was made in the study of factors affecting the setting of fruit on the tomato. Minute insects were found which ate the pollen. The varieties of the cherry type of tomato, which have a large amount of pollen, seemed to suffer least. Observations were also made to determine whether bees or other insects were necessary to carry the pollen of tomatoes. The destruction of the pollen by *Thrips tritici*, however, has raised a serious problem of improving the pollination of tomatoes.

Histological studies were made during the winter to determine the changes which occur at the point of union of the graft and the stock into which it is inserted. Some progress was also made in preparing for the study of the effect of cultural operations and fertilizers in modifying the development of fruit buds.

*Work with Hatch and other funds.*—Several lines of work were carried on with the support of Hatch and other funds. The area under experiment by the agronomy department was reduced to 60 acres, being used for strictly experimental work. Attention was given to Sudan grass, grain sorghums, sweet sorghums, alfalfa, legumes, cotton breeding, plowing at different depths, and types of Bermuda grass.

In hog feeding cottonseed meal was compared with meat meal as a supplement to corn. Some pasturage experiments with late lambs were also carried on. In comparing alfalfa and cowpea hay for dairy cows it was found that individual animals showed a preference for one or another of these hays. Cowpea hay appeared to have a feeding value equal to that of alfalfa. Bermuda hay proved less palatable than prairie hay and less effective in milk production. Bermuda pasture, however, seemed to be of more value than prairie pasture. Grazing for one hour on wheat pasture seemed to be equal in milk production to 10 pounds of roots. Some experiments were carried on in the storage of butter, gas-producing organisms in cream, hog cholera, and various other animal diseases.

Along horticultural lines studies were continued on pecan varieties, dynamiting land for fruit planting, varieties of fruit trees, seed grading, Jack beans, grapes, and varieties of small fruits. Information was also collected regarding the status of beekeeping in Oklahoma and of miscellaneous insect pests.

The publications received from this station during the year were as follows: Bulletins 99, Dairying in Oklahoma: Some Results Obtained in Feeding Dairy Cows, Principles of Feeding, Feeding Dairy Cattle, and Experiments in Milk Production, Care and Management of Dairy Cattle; 100, Garden and Truck Crop Insect Pests; Circulars of Information 16, Bermuda Grass; 19, Spanish Peanuts; 20, Systems of Planting Orchards; 21, Fruit Packages in the Middle West; 22, Preserving Fruits for Exhibition Purposes; 23, Hotbeds; 24, Burn the Bugs; 25, Sweet Potatoes; 26, Deep Plowing and Sub-soiling; 27, Food from the Grain Sorghums, Feterita Products; 28, Information Relative to Beekeeping; 29, Jack Bean (*Canavalia ensiformis*); and the Annual Report, 1913.

The income of the station during the past fiscal year was as follows:

|  |            |
|--|------------|
| United States appropriation, Hatch Act | \$7,649.08 |
| United States appropriation, Adams Act | 8,517.91   |
| State appropriation                    | 5,000.00   |
| Farm products                          | 3,241.15   |
| Miscellaneous                          | 2,137.06   |
| Total                                  | 26,545.20  |

The Oklahoma station has passed through a very trying experience, marking the culmination of a mistaken policy of management which has centered the administration in the board instead of the director, has shown small regard for the rights or welfare of the station, and has deprived positions on its staff of the security which justice and merit demand. It is hoped that it has now been removed from the strife of the past and provided with a greater measure of opportunity and of freedom from unwarranted interference in its management and its funds and greater security of position. Prospectively, the outlook seems improved for the station to be allowed to realize the great opportunity which is open to it.

#### OREGON.

*Oregon Agricultural Experiment Station, Corvallis.*

A. B. CORDLEY, M. S., *Director.*

Dr. James Withycombe, after nearly 16 years of service as director of the station, resigned to engage in private work, and Prof. A. B. Cordley was appointed in his place. The new director will devote all his time to administrative work. A more complete separation was made between the work of the station and college, all of the farms being taken over by the college, which pays maintenance charges for farms and live stock.

The branch stations, five in number, and maintained at State expense, continued their operations satisfactorily. The facilities at the main station for work in animal feeding, dairying, and poultry raising were materially increased. A barn with a floor space 52 by 120 feet was erected for use in experiments with beef cattle and sheep. The poultry equipment was increased by several buildings especially planned for this work. The main poultry building is a three-story structure containing rooms for laboratory and demonstration purposes, an equipment of tools, benches, storage rooms, and also rooms for fattening and killing fowls, for incubation purposes, and for grinding and preserving feeds. Representatives of several breeds of live stock were added to the equipment of the department of animal industry. The creamery was also remodeled and its equipment and capacity increased.

*Adams fund projects.*—Decided progress was made in the study of the pollination of the apple and pear and other features connected with the development of the fruit. It appeared that the major part of the edible portion of the apple and pear is of the same nature as the tissue composing the stem, and that therefore only those conditions which modify stem structures can be expected to modify the edible portion of the fruit. The fruit is not modified directly by

the influence of one or another kind of pollen. A study of developing buds in different positions on the tree indicated that differentiation into fruit and leaf buds takes place at different times. The fibro-vascular system of the apple was studied in great detail and cytological investigations carried out on the pollen and ovules of the apple and pear.

The problem of orchard irrigation was investigated with particular reference to the pear. It appeared that different amounts of water produced no perceptible difference in the time required for trees to leaf out fully. Large amounts of water produced larger and more brightly colored leaves. The time of starting of the buds was not affected by water supply. In general, the greatest number of blossom clusters, the greatest average size, weight, and best quality of fruit, and greatest total amount of wood growth were produced on trees which received an excess of water. The study of apple pruning and its effect on the development of buds was begun with 1,200 one-year-old apple trees. The effect of freezing on pollen was studied during the spring, and also the problem of critical temperatures for orchard fruits. The work of pruning and critical temperatures has been carried on only one year.

Much cultural work and repeated inoculations were made in the study of cherry gummosis. Similar troubles were found on other related fruits, and several strains of the organism causing the disease had been found. The Lambert cherry appeared to suffer less from this disease than the Bing or Royal Ann. It was also proved that the Mazzard type of seedling is quite resistant. From various sources new bacterial strains were isolated, most of them similar to *Bacillus cerasus*. The bacteria were repeatedly demonstrated in the lesions of the disease and rather convincing evidence was obtained that the disease is due to their presence. A rapid callus formation occurred on wounds produced by cutting out the diseased spores and apparent recovery from the trouble took place. Apple anthracnose was found on the pear and quince as well as upon apple. Further studies are being made on the distribution and control of this problem.

A systematic study was continued of the bark beetles of the State, a large collection being accumulated, and a study being carried on of forestry and lumbering methods, and the possible bearing of their control on these pests. Complete records are also being kept upon the symptoms of the attack of bark beetles, the effects of these pests upon the tree, and the details of their life history. In further studies of red spiders notes were taken on color variations, and four new species, all of economic importance, were discovered. Several new natural enemies were noted and their importance in the control

of these pests will be studied further. In attempts to control red spiders, fumigation, evaporation of sulphur, and spraying with various materials were tried on hops, pears, violets, tomatoes, melons, and other plants.

The results obtained from a study of the chemical changes in hops due to sulphuring were of considerable interest. Apparently the bitter resins were not affected in the bleaching process by sulphur, neither did the sulphur dioxide combine with the essential oil of the hop. It was found that the unsulphured hop contains sulphur in the sulphate form, but no volatile sulphur. Analytical methods which had previously been used for the estimation of the amount of sulphur were found to be unreliable.

In continuing the chemical investigation of spraying materials the station succeeded in preparing hydrogen arsenate in pure form. All attempts to prepare neutral lead arsenate failed, and it appears that this compound does not occur in the ordinary lead arsenate material. The principal constituent of commercial neutral arsenate of lead proved to be a basic arsenate. Experiments are being carried on to determine the insecticidal value of different lead arsenates. The chemical study of lime-sulphur spray resulted in the perfection of simple methods for the determination of the amount of calcium hydroxid in lime sulphur. The polysulphids in solution proved to be probably a mixture of tetrasulphid and pentasulphid of calcium. It was found that a considerable amount of sulphur in the solution is freely combined and for practical purposes may be considered sulphur in physical solution.

About 500 chemical determinations were made of six types of Oregon soil in the study of the ammonifying and nitrifying efficiency of these soils. The soils varied from very acid to alkali in reaction. The number of bacteria in soils low in organic matter was small as compared with the number in peat and muck soils. A direct correlation was observed between the amounts of ammonia and the number of bacteria. Lime caused a decrease in the number of bacteria and in the ammonifying and nitrifying powers of some of the soils, while in others it had little or no effect upon nitrification or ammonification. The ammonifying powers of the soils vary greatly, a high amount of ammonia being produced in light soils.

The purpose of the investigation carried on in the incubation of eggs is to learn the cause of failure to hatch and of the mortality of chicks. It was shown that the humidity surrounding the eggs during incubation is of great importance. Humidity, taken in connection with ventilation, seemed to be the main factor to be reckoned with in solving the problem of losses of eggs in incubation. The moist incubator gave decidedly the best results, in some cases proving more

effective than hens. In this work analyses are being made of incubator chicks and hen-hatched chicks on the eighteenth day of incubation.

*Work with Hatch and other funds.*—Oregon station carried on, as heretofore, a large variety of work with the support of Hatch and other funds. Among 196 varieties of strawberries tested at the station, 8 varieties were found to approach the ideal commercial standpoint. A large number of seedling strawberries have been grown, and of these two gave great promise. Much attention was given to the propagation of the loganberry and its uses. It was found that even by crude methods 75 per cent of the juice could be recovered in a commercial form, the amount of juice recovered showing a close relation with the length of time the berries stood before being pressed. The ripe berries gave the higher percentage of juice. The acidity of juice ranged from 1.78 to 1.88 per cent, and the sugar content was about 6 per cent. The commercial utilization of loganberry by-products appeared to be a promising industry.

The results obtained from the study of cherry pollination were of considerable interest. All varieties of sweet cherries utilized in the experiment proved to be self-sterile. The self-sterility, however, was due in no case to the lack of germination of the pollen, but apparently to physiological properties not well understood. Inter-sterility of sweet cherry varieties was apparently not correlated with their closeness of relationship. It appeared that the ability of a variety of cherry to set fruit is not entirely dependent upon the kind of pollen available. Some of the seedling trees in cherry orchards were shown to be efficient pollenizers for the Bing, Lambert, and Napoleon varieties.

The plant diseases to which particular attention was given were potato diseases caused by a Fusarium, Rhizoctonia disease, scab, a late blight both on the tomato and potato, a brown rot of prunes, mushroom root rot of apple, cherry, peach, and other fruits, rust on the pear and quince, and crown gall of peaches.

A number of eastern ladybird beetles, including *Megilla maculata*, were introduced and are being reared in confinement. A test is being made of the value of these ladybird beetles under Oregon conditions. A great variety of practical work in entomology was carried on during the year. This work included a study of the life history of the woolly aphis of the apple, currant fruit fly, cucumber beetle, strawberry root weevil, cherry fruit fly, bud moth, and other insect pests, as well as numerous tests of insecticides with or without the addition of fungicides.

It appeared that arsenite of zinc is a poison of quicker action than arsenate of lead, either in the acid or nonacid form, and remains

longer in suspension. The nonacid arsenate of lead was found to be comparatively slow in its action. The combination of lime-sulphur with arsenicals appeared to retard somewhat the action of the arsenicals upon the insect larvæ. The injury caused by lime-sulphur was found to be due chiefly to calcium polysulphids and to a less extent to calcium thiosulphate. Other normal ingredients in lime-sulphur spray proved to be harmless to fruit or foliage. Rain following an application of the spray tended to decrease or prevent its injury.

A large number of miscellaneous analyses were made of soils, fertilizers, feeding stuffs, mineral waters, insecticides, and fungicides. In the presence of semiarid alkali conditions of the soil the activity of the nitrogen-gathering bacillus was found to be greatly checked. Numerous bacteriological examinations were made of water and other materials submitted to the station. Work was also begun on tuberculosis and white diarrhea of fowls.

In hog-feeding experiments it was found that the use of the self-feeder was economical and produced extremely rapid gains. The cost of pork production in one experiment in which wheat tankage and shorts were used was \$6.81 per hundred pounds. The results obtained from a test of shelter for lambs in winter indicated that the rate and economy of gain were favored by shelter. Breeding poultry for high egg production was continued. The yield increased during the year, and the station now has a large flock of layers with pedigrees dating back for three years from stock laying 200 or more eggs per year.

The successful use of silage in midsummer is reported. Under the climatic conditions which prevail at the station, silage is more needed in midsummer than in winter. No difficulties were experienced in preserving silage for use at this time. Numerous variety tests were made with legumes, soy beans, corn, cereals, kale, and potatoes. The maximum yield was obtained with potatoes with the moisture content 20 per cent in the first foot of soil, while the best results with clover occurred with a moisture content of 15 per cent.

The cost of producing various crops was studied and reliable data obtained along this line. It has proved to be a profitable farm practice to irrigate in the Willamette Valley during the periods of drought. In the study of moisture movements in soils it appeared that with thorough cultivation the surface moisture could be made to join the moisture from the water table in a region where the water-carrying stratum lay at a depth of 12 to 18 feet below the surface.

The publications received from this station during the year were as follows: Research Bulletin 2, An Investigation of Lime-sulphur Injury—Its Causes and Prevention; Bulletins 115, First Biennial Report of Umatilla Experiment Farm, Hermiston, Oreg., and of

Southern Oregon Experiment Station, Talent, Oreg.; 116, A Preliminary Report on the Pollination of the Sweet Cherry.

The income of the station during the past fiscal year was as follows:

|   |                |
|---|----------------|
| United States appropriation, Hatch Act                    | \$15,000.00    |
| United States appropriation, Adams Act                    | 15,000.00      |
| State appropriation, including balance from previous year | 80,943.99      |
| Farm products, including balance from previous year       | 7,653.30       |
| Miscellaneous   | 16,118.92      |
| <br>Total   | <br>134,716.21 |

The work of the Oregon station is increasing in effectiveness from year to year, both along research and practical lines. Corresponding with the increase in efficiency of the station organization there is noted an increased sympathy of the farm population and recognition by the State authorities.

PENNSYLVANIA.

The Pennsylvania State College Agricultural Experiment Station, *State College*.

R. L. WATTS, B. Agr., M. S., *Director*.

Neither the work nor the staff of the Pennsylvania station underwent any noteworthy change during the year. The plan of organizing the research work of the station was somewhat modified, a research committee composed of the heads of the departments being appointed to have charge of this matter. Such a committee was found helpful in more closely correlating the extensive list of problems which are being investigated by the station.

A special State appropriation of \$6,000 was made for experiments with tobacco, \$75,000 to complete the horticultural building, and \$25,000 for a new dairy barn. The barn consists of a group of buildings arranged around three sides of an open court. It is equipped with all modern improvements.

*Adams fund projects.*—The study of the effect of fertilizers upon apples and peaches involved during the year 13 cooperative fertilizer experiments on a rather extensive plan in different parts of the State. It is hoped that this work will result in the determination of a good fertilizer formula for preliminary use on the orchards. The efficiency of the proper mulch in conserving moisture and producing a superior growth and fruit yield, especially on young trees, was clearly shown.

No striking developments occurred in the continuation of study of the long-time fertilizer plats. It appeared that where lime had been used in large amounts 50 to 60 per cent of the lime applied was still

present in the upper 21 inches of soil. Pot experiments with different forms of lime indicated that the finer pulverized raw limestone was equally as prompt and effective in correcting acidity as equivalent amounts of burned or caustic lime. Lime too coarse to pass through a 60-mesh sieve had little effect in correcting acidity or in promoting the growth of clover. It was found that red clover was tolerant of soil acidity up to the equivalent of 1,500 pounds of calcium oxid per acre in the top 7 inches of soil. Some progress was also made in the study of the bacterial flora of certain of the fertilizer plats and in determining the comparative effects of calcium and magnesium upon the organisms of nitrification.

The Adams fund work in animal husbandry was carried on in the Institute of Animal Nutrition. A study of the heat development of the animal body resulted in some interesting and important determinations. The observed heat production from definite food materials differed by only 0.41 per cent from the theoretical computed heat production of the same materials. These results are taken as demonstrating that the conversion of the energy of feeding stuffs by farm animals into heat and work is governed by the same laws that apply to the combustion of material outside of the body. It is held, therefore, that heat in the animal body arises exclusively from the combustions which occur in the body. These results were obtained by 57 experiments of two days each on 7 different animals.

*Work with Hatch and other funds.*—The work carried on under Hatch and other funds involve a wide range of problems. In agronomy this work involved variety tests with wheat, oats, potatoes, and corn, selection of corn and timothy, farm management, fall versus spring plowing, rotation with reference to lime requirements, miscellaneous tests of cultural methods, and varieties of oats, wheat, soy beans, and alfalfa, and fertilizer experiments. The great variation in the yield of the same varieties of wheat in different years led to the conclusion that not much dependence can be placed upon such tests unless they are carried on for four years or longer. In most of the variety tests with wheat, Dawson Golden Chaff gave the largest yield. A study of the limestone and lime supplies of Pennsylvania showed that all of the samples examined were low in magnesia, that there was a great range in the percentages of lime and magnesia in the samples, and that the ground forms of lime were low in carbonate but contained 6 to 7 per cent of water of hydration. On most of the limestone soils of the State, phosphorus was found to be the dominant fertilizer requirement. Neither potash alone nor nitrogen alone gave increase in plant growth without the use of phosphorus. General field experiments with burnt lime and pulverized raw limestone showed the best results from pulverized limestone.

The principal work along the line of forestry included the growing of thousands of seedlings of various species to determine the best methods of propagation and treatment, in which is included a study of the methods of propagating basket willows and an investigation of the effect of wrought iron and wire nails on the durability of shingles.

The horticultural studies during the year involved variety and cultural tests with cabbage, asparagus, tomatoes, and the study of inheritance in tomatoes. A general survey was made of apple growing in Pennsylvania. In a comparison of various strains of the Earliana type of tomatoes it was found that a variation of more than 13 tons per acre of marketable fruit occurred. This variation was attributed to heredity rather than environmental conditions. It is recommended that seed be secured one year in advance of large plantings in order that the yielding power of the strain may be determined.

In the department of animal husbandry the projects which received most attention were maintenance ration for breeding flocks of sheep and beef cattle, a comparison of different rations for pork production, a comparison of egg yield of hens running at large and confined, the production of winter chickens for spring market, and the production of draft horses.

For feeding steers, corn silage at \$3.50 per ton proved more economical as the exclusive roughage for steers than the combination of silage and hay. The corn silage was found to be more palatable than ear corn. The net profits received from feeding cattle varied from \$11.20 to \$14.09 per head, with an additional profit of \$2.23 per head when hogs were allowed to follow the cattle. A series of observations on the production of draft horses indicated that the average gain in weight during the first 532 days was 720 pounds, the average daily gain gradually decreased as the age of the colts increased, the average cost of feeding colts of the draft-horse breed for the first year after weaning was \$53.97.

As a result of a comparison of the various strains of tobacco grown at the station 4 out of the original 27 strains were retained. The best results were secured by planting tobacco 28 inches apart in rows  $3\frac{1}{2}$  feet apart. The burn of the tobacco was much improved by applying 200 to 300 pounds of potassium sulphate per acre in addition to barnyard manure. Steam sterilization of seed beds was found to be decidedly beneficial. It is recommended that tobacco seeds should not be sown on the beds until at least 24 hours after sterilization.

A comparison of open-shed with regular stabling for dairy cows shows that in the open shed cows will consume more roughage than in stables, but that the milk yield in the outside lot of cows decreased

more rapidly each winter than that of the inside lot. Extensive observations were made on the conditions under which farm butter is produced and methods of improving it. It was concluded that cream should not be allowed to ripen to more than 0.5 per cent acid. A general survey was made of the prevalence of tuberculosis in dairy herds. Tests were also made with milking machines, mixed feeds for dairy animals, silage as a sole roughage for dairy cows, and on the comparative merits of different bedding materials.

The chief result from studies in plant pathology was that collar rot in apples is but a phase of blight due to *Bacillus amylovorus*. Work was also continued on rusts of apple and forest trees and upon the effect of smoke on vegetation.

The following publications were received from this station during the year: Bulletins 122, Developing Draft Colts; 123, The History of Tuberculosis in the College Herd; 124, Steer Feeding Experiments at the Pennsylvania State College; 125, Tests of Varieties of Wheat; 126, Food as Body Fuel; 127, Pennsylvania Lime Stone and Lime Supplies; 128, The Apple in Pennsylvania—Varieties, Planting, and General Care; 129, Strain Tests of Tomatoes; and 130, Tobacco Seed Beds.

The income of the station during the past fiscal year was as follows:

|  |               |
|--|---------------|
| United States appropriation, Hatch Act-----              | \$15,000.00   |
| United States appropriation, Adams Act-----              | 15,000.00     |
| State appropriation -----                                | 6,000.00      |
| Fees -----   | 14,067.00     |
| Farm products, including balance from previous year----- | 24,818.38     |
| Miscellaneous-----                                       | 117.71        |
| <br>Total -----  | <br>75,003.09 |

The Pennsylvania station continues to make satisfactory contributions to the knowledge of Pennsylvania agriculture, and by means of the numerous practical problems with which it deals is brought into close sympathy with the farming population.

The Pennsylvania State College Institute of Animal Nutrition, *State College*.

H. P. ARMSBY, Ph. D., LL. D., *Director*.

In addition to the results of the investigation upon the source of heat in the animal body, published as Bulletin No. 126 of the Pennsylvania station and referred to above, the Institute of Animal Nutrition carried on a study upon the influence of the condition of fatness upon the utilization of feed by cattle. General experience has shown that with the progress of fattening a greater total amount of food is required to produce a given increase in weight. The object of this investigation is to determine as accurately as possible the

cause of this phenomenon, particularly whether it is due to an increased maintenance requirement, to a smaller consumption of food, or to a difference in assimilating power.

Much time has been given to a simplification of apparatus and method necessary to make the vast number of computations in the work in animal nutrition. A modified bomb calorimeter which simplifies the energy determinations is one of the recently devised pieces of improved apparatus.

From a study of the influence of standing or lying upon metabolism of cattle it was found that the mere act of standing increased the amount of radiated heat from 34 to 39 per cent, the amount of carbon dioxid excreted from 28 to 30 per cent, and the amount of water vapor excreted from 31 to 33 per cent. The increased emission of heat while the animals were standing was accompanied by a correspondingly increased elimination of both carbon dioxid and water vapor. It was concluded, therefore, that the increased heat emission during standing represented substantially the increase in heat production during the same time.

A careful investigation was made of the combustible gases excreted by cattle. In this study it was found that the amount of combustible gases increased with the increase in quantity of feed eaten. The production of combustible carbon was relatively greater with smaller rations. In percentage of total carbon given off in carbon dioxid the combustible carbon increased with the increase in the rations. These phenomena appeared to have no relation to the individuality of the animals concerned. In all the experiments in the prosecution of this study an excess of carbon over hydrogen was found. For this phenomenon no satisfactory explanation has thus far appeared.

During the year the data with reference to the maintenance requirements of cattle were summarized in Bulletin 126 of the station.

The importance of the work of the Institute of Animal Nutrition is increasing from year to year. It is throwing more and more light upon the fundamental problems of animal physiology chiefly concerned in the study of nutrition.

#### PORTO RICO.

Porto Rico Agricultural Experiment Station, *Mayaguez*.

D. W. MAY, M. Agr., *Special Agent in Charge*.

As heretofore, the station devoted its energies chiefly to a solution of problems which have arisen in the diversification of Porto Rican agriculture. The process of diversification has rapidly increased and extended under the feeling that one crop system could not always pre-

vail, and particularly since such pronounced success has attended the efforts to develop the fruit industry of Porto Rico. The value of the fruit produced in the Territory during the last year exceeded \$3,000,000.

There were no changes in the station staff. A plant laboratory, inclosed with glass and wire netting and furnished with conveniences for pot experiments, was erected, and the old sugar mill on the station grounds was transformed into a soils laboratory.

In order to promote and encourage in a substantial way the present diversification of agriculture in Porto Rico, promising plants are being imported from the various tropical countries. The horticultural investigations embraced an orchard survey of the island, including a study of soils, climatic and other conditions in various localities, and statistics on the present status of the various industries. Systematic studies are being made on the acclimatization of imported plants and on the influence of soil, cultivation, and topographic exposure.

Several thousand grafted trees of improved varieties of mangoes have been distributed in different districts of the island, and notes have been kept on the growth, time of bearing, and appearance of the fruit produced in different districts. A method of grafting has been devised which appears to be more convenient and quicker in results than inarching. The use of fertilizers and green manuring for cocoanuts continued to receive attention. Queensland nut and Brazil nut give promise of being important trees for Porto Rico.

A study of coffee plantations involved particularly a survey of the old groves, with the idea of improving the yield and financial profits from coffee by rational methods of handling. The *Columnaris* variety of coffee has thus far yielded the best results. The trees proved to be vigorous and of large size.

Efforts are being made to secure and distribute better varieties of cacao and to improve the method of curing the beans. The station's vanilla planting has reached a stage of development at which selections of the best types can be made to be distributed to farmers, particularly to coffee growers, for the purpose of inducing them to produce vanilla beans in connection with their coffee groves.

The work in forestry included chiefly the growing and distribution of seeds of cabinet woods, rubber trees, and leguminous shade trees. About 200 acres of land belonging to the insular government was set out to such trees during the year. From this forest planting large numbers of trees have been distributed throughout the island.

Among the leguminous crops which have been studied at the station Japan clover and a species of *Stizolobium* have proved most promising. The Japan clover has been promiscuously distributed along roadways in order to enable this plant to spread over the

islands. *Stizolobium* has been distributed as a green manure for citrus groves and in cane fields. Cultures of nitrogen-fixing bacteria were obtained and generally distributed, in order to improve the growth of leguminous crops. Among the grasses tested at the station the Sudan grass gave the best results, and is at present perhaps the most promising grass on the island.

Systems of rotation were studied by means of cooperative experiments with cane planters. Since it has been found necessary either to rotate cane with some other crop or to rest the land occasionally, an effort was made to devise a practical system of rotation. Some of the cane planters have been induced to grow leguminous crops rather than merely to allow the fields to return to grass between crops of cane. In these cooperative experiments a study was also made of fertilizers for cane.

The live-stock investigations of the year were confined largely to cattle breeding and the subject of milk production. The importations of improved stock made by the station for its own uses and for breeders has already shown excellent results in the better class of animals to be seen throughout the island.

In the field of chemical investigation a study is in progress on the rôle of mineral nutrients in feeding live stock. Thus far special attention has been given to lime. The availability of various forms of phosphatic fertilizers accessible to citrus growers received much attention. Other chemical studies involved an investigation of the assimilation of iron by rice, the connection of lime with chlorotic areas in cane fields, the red clay soils of Porto Rico, and a study of the cause of their acidity. Red clay was found to be one of the most extensive soil types on the island, and to be characterized chemically by a high percentage of iron and aluminum, moderate amounts of nitrogen, phosphoric acid, and potash, and an absence of carbonates. The soil is almost uniformly acid.

The entomological investigations were confined chiefly to the study of methods of controlling the mole cricket. This pest has proved to be difficult to combat by poisonous insecticides or other artificial remedies, and some effort has been devoted to the finding of natural checks which may keep the pest under control. The subject of bee-keeping received considerable attention, and studies were made on the diseases of coffee, citrus fruits, cacao, coconut, banana, and vegetables.

The publications received from this station during the year were as follows: Bulletins 11 (Spanish edition), Relation of Calcareous Soils to Pineapple Chlorosis; 13, Studies on Acid Soils of Porto Rico; 14, The Red Clay Soil of Porto Rico; 15, Porto Rican Bee-keeping; and the Annual Reports for 1912 and 1913.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation-----                 | \$30,000.00 |
| Sales, including balance from previous year----- | 2,699.85    |
| Total -----                                      | 32,699.85   |

The general interest among the farmers of Porto Rico in the station increased greatly during the year, requests for advice and assistance have multiplied rapidly, and completion of a road around the island put the station into closer touch with other districts of the island than heretofore, with the result that the number of planters who came to inspect the station experiments increased greatly.

#### RHODE ISLAND.

Rhode Island Agricultural Experiment Station, *Kingston*.

B. L. HARTWELL, Ph. D., *Director*.

Most of the work of the Rhode Island station is concerned with agricultural research of a fundamental nature. The two most important lines of investigation during the year were probably poultry problems and the study of the influence of various crops upon the growth of succeeding crops. There were no important additions to the equipment of the station. The work in all the lines of research was continued without interruption and no important changes occurred in the staff.

*Adams fund projects.*—Attempts to control blackhead disease of turkeys by separation of infected birds were not successful from a practical standpoint. Various methods of feeding and kinds of feed were tried in an effort to bring about curative results. These experiments produced evidence that hope may be entertained of successful cures of blackhead by feeding a ration containing corn meal, wheat bran, middlings, granulated milk, and linseed meal, with an addition of sour milk at the rate of about 0.3 quart per bird per week beginning with the third week and increasing the amount as the birds become older. This ration should be accompanied with the use of an intestinal antiseptic, particularly beginning with the thirty-fifth day of age. This method of treatment not only appeared to act as a preventive but to some extent as a curative of blackhead.

The study of the laws governing inheritance in domestic birds was continued, attention being given chiefly to the constitution of the White Leghorn breed and the inheritance of colors in pigeons. A special effort was made to determine the method of production and the inheritance of the barred color patterns. Crosses were made between White Leghorns and Black Spanish, Black Minorca, Black Langshan, and other black breeds. The evidence thus obtained indi-

cated that the barring was not in any case produced from the crossing, but was due to a factor for barring present in one of the parent birds. It appears improbable, therefore, that the barred character can be produced by crossing breeds not possessing this factor for barring.

The inheritance of color in Tumbler pigeons was carefully investigated. These birds showed in their plumage black, red, yellow, dun, white, and silver colors. It appeared that certain birds possess an intensifying factor which produces a pronounced red or black in the offspring. Otherwise the red appears to be yellowish and the black as dun.

The work on fowl cholera during the year made decided progress. Rabbits were studied as a possible source of an immunizing serum. It was found that female rabbits immunized by inoculation with a nonvirulent culture of fowl cholera transmit a high degree of resistance to their offspring for a period of at least two years and three months after the date of immunization. The resistance in the offspring proved not to be permanent but limited to 40 days.

A vast difference in virulence was found to exist between different strains of the fowl-cholera organism. Among 17 strains of fowl cholera bacterium which were tested for their resistance-producing power toward a highly virulent culture, only one was found which produced any measurable resistance. This culture invariably gave perfect immunity. The immunizing culture in question was tested against five other virulent strains and it proved to be protective against three of them. This method of immunization which has been satisfactorily worked out on rabbits will be employed perhaps with modifications in an attempt to immunize fowls.

In pursuing the study of the losses in incubator chicks examinations were made of 5,000 eggs to determine the normal bacterial flora of eggs in its relation to hatching.

The study of the effect of crops upon the growth of following crops was continued, 16 crops being under experiment. The results indicated that the effect of certain crops on succeeding ones is not limited to a modification of the supply of plant food, but appears to include variable factors which act differently on different plants. Onions were found to be very sensitive to soil activity, and to be greatly lowered in yield by a previous crop of buckwheat. The yield of onions under different conditions varied from 12 to 400 bushels per acre. A variation from 4 to 35 bushels per acre in buckwheat was produced in different rotations, the crop being almost uniformly poor when following clover.

In the continuation of soil acidity work it was found that barley was injuriously affected by an acid condition, while rye proved resistant to soil acidity. In sand cultures and in solutions with differ-

ent forms of acidity, however, barley and rye gave practically the same results. When these cereals were grown in a soil extraction prepared from an acid soil the results were the same as were secured under field conditions.

The study of the effects of deficiencies of phosphorus and potash on the growth of plants brought evidence that the present analytical methods were unsatisfactory for the quantitative determination of phosphorus in the tissues and juice of turnips. Potatoes were grown with medium and low potash applications, the best results being secured from the latter. The nitrogen content of potatoes was highest where potash had been withheld, the nitrogen, however, being largely in a nonproteid form.

The final forms of protein concentrates to be studied with reference to their suitability for growing chicks were beef scrap and cottonseed meal. Pepsin-pancreatin extract, made from the cottonseed meal, showed no harmful effect upon rabbits and hens to which it was fed, and appeared not to be toxic in any way. It is considered more important in the growth of young chicks that the amount of protein be sufficient than that it be associated with definite proportions of carbohydrates and fat. If the constituents of bone are otherwise supplied, it is considered that cottonseed meal may well be used to furnish a considerable portion of the protein required by young chicks.

The investigation of the effect of modifications of physical and chemical conditions of the soil upon carnations and roses in greenhouses was practically completed. In connection with this work a study was made of the effect of various compounds upon the retention of freshness in cut roses. In these experiments a considerable number of salts, acids, and other chemicals was tested. Of all the materials used sugar alone caused any marked freshening in the appearance of the flower. Sugar was used in a solution of 7 to 10 per cent.

*Work with Hatch and other funds.*—A considerable amount of work was carried on by the aid of Hatch and other funds. Corn gave only poor yields with chemical fertilizers, except where leguminous green manuring was applied. During the year a study was made of the effect of soils with a deficiency of potash upon the growth of potatoes, rape, and onions as compared with previous effects noted on carrots. Fertilizers with alkaline residues were found to promote the growth of weeds in lawn plats. No specific effect of the various potash salts was noticeable, for the reason that the plat from which potash had been withheld for a number of years still produced a normal crop.

On an equal calcium basis it was found that only that portion of ground limestone which would pass an 80-mesh sieve was as useful

to the first crop in correcting acidity as slaked lime from the same original rock. Coarser siftings were useful in proportion to their fineness.

The publications received from this station during the year were as follows: Bulletins 155, Studies on Inheritance in Poultry, I; 156, The Availability of the Nitrogen of Cottonseed Meal and Beef Scrap for Chicks; Inspection Bulletins, September and October, 1911, Analyses of Commercial Fertilizers; May, 1913, Analyses of Feeding Stuffs; June, September, and October, 1913; Analyses of Commercial Fertilizers; and the Annual Report for 1912.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----            | \$15,000.00 |
| United States appropriation, Adams Act-----            | 15,000.00   |
| Miscellaneous, including balance from previous year--- | 6,060.81    |
| Total-----   | 36,060.81   |

The work of the Rhode Island station is of high grade from a scientific standpoint and is rapidly furnishing a solid basis for the rational development of the agriculture of the State.

#### SOUTH CAROLINA.

South Carolina Agricultural Experiment Station, Clemson College.

J. N. HARPER, M. Agr., *Director.*

All the work of the station and of the branch stations was prosecuted on a project basis. Two branch stations were maintained, one on the lower pine belt and the other on the Orangeburg sandy loam. The organization of the station was not materially changed, and good progress was reported in most lines of work. T. R. Risher resigned as assistant chemist, and his place was filled by the appointment of C. J. King. In order to keep more systematic records of the work of the branch stations, daily reports are furnished to the main station showing just what is being done for the several departments of the main station.

*Adams fund projects.*—Encouraging progress was made in the study of partial insolubility of potash salts when mixed with basic slag. It was found that whenever muriate of potash or kainite is mixed with basic slag a part of the potash which was previously soluble becomes insoluble. The insolubility was apparently due to the formation of a compound insoluble in water but soluble in hydrochloric acid. Work was begun on the extension of the project relating to the effect of iron in the soil upon the determination of soluble potash. An electrolytic method was devised for throwing

out the iron in metallic condition and preventing occlusion of the potash in the precipitate.

Six cattle were used in the study of the effect of feeding large amounts of cottonseed meal to cows. The cows were divided into three lots of two each, of which one lot received little or no cottonseed meal, the second received a high protein ration, mostly linseed meal with a small amount of cottonseed meal, while the third lot received a high protein ration entirely from cottonseed meal. The amount of cottonseed meal in the ration was as high as 6 pounds a day. Analytical determinations are being made of the feeds used in the experiment and of the excretory products of the animal. Striking differences were found in the toxicity of different samples of cottonseed meal in rations for pigs. No sample, however, proved decidedly toxic to pigs. In this investigation pigs of both the lard and bacon types were used, and ether, alcohol, and hot-water extracts were fed with somewhat uncertain results. Little progress was made in the investigation of the factors affecting the composition of cottonseed meal. The work was chiefly along the line of separating different forms of phosphoric acid.

Difficulty was experienced in securing a complete control of moisture conditions in the study of the relation of temperature and moisture to insect activity. The effects so far noted appear to be due to a combination of temperature and moisture. Some success was had in devising apparatus for the purpose of controlling accurately the percentage of moisture. It is hoped to show by means of this contrivance the conditions under which parasites can be best maintained. Considerable success was had in devising remedies for the control of strongyloid parasites in the intestinal tract of ruminants. In the further study of the slender wireworm the temperature and moisture of the soil was determined as the worms were collected. The results thus obtained indicate that the pest could be in part controlled by the systematic use of cover crops.

No variety of cotton was found which showed much resistance to cotton anthracnose. A study of the life history of this fungus showed that it remains in the field for about one year. When buried deeply in the soil, however, the organism fails to live more than six months. A rotation was recommended as a practical means of controlling this disease. In heating cotton seed to prevent the development of anthracnose it was found that there is a difference of about 20° C. between the thermal death point of the fungus and of the cotton seed. The cotton seed withstood a treatment of 75° C. in water for 10 minutes without injury. This temperature destroyed the fungus.

The cause of shedding squares in cotton appeared to be a physical one, due in large part to an excessively dry condition of the soil. It

was found possible to control it by means of irrigation. Incidentally the water requirement of the cotton plant was studied in pot cultures, with the result that only two-thirds as much water was found necessary for producing a good growth of cotton in fertile soils as in poor soils.

A great variation was found in the percentage of cuttings of *Rotundifolia* grapes which could be made to root in the greenhouse at different seasons of the year. The highest percentage of success was attained in May, June, and July. In this work the Scuppernong and 12 or more other varieties were studied. An attempt was made to determine whether these grapes are self-sterile. By the use of pollen of a staminate variety a larger set was secured than where flowers were pollinated from the same variety. Some attention was given to the study of the agency of insects in fertilizing these grapes. During the year about  $2\frac{1}{2}$  acres of ground were used in the investigation.

Better results were obtained with corn in using pollen from fertile stalks than from barren stalks. Only a small number of barren stalks were found for the purpose of the experiment, but the ear was located higher on the stalk when pollen from barren stalks was used for fertilization.

The study of the relation between the soil and the length and quality of staple in cotton was continued actively. Plants were grown in different localities, but it is proposed to bring soil from these localities to the station in order to eliminate climatic influences. About 10 varieties were used and the experiment was extended to include cooperative work with farmers representing typical soil areas. Some indication was obtained that fertilizers exert an effect on strength of fiber.

*Work with Hatch and other funds.*—Hatch and other funds provided means for carrying on a considerable variety of experiments. Fertilizer tests were conducted comparing half and double amounts of each constituent in standard commercial fertilizer mixtures. This experiment was carried on in connection with rotation of cotton, oats, corn, and cowpeas.

The entomological department studied the distribution, life history, and methods of controlling the lantern fly (*Peregrinus maidis*) on corn. In the control of this pest it was recommended that immediately after harvesting the stalks should be cut up, plowed under, or otherwise destroyed. In small gardens some success was had by spraying with kerosene emulsion or whale-oil soap. For the control of the cotton-root louse it was recommended that a shallow system of cultivation be put in practice as soon as the ants are noticed about young cotton plants in the spring. It was recommended that the process be continued until the cotton has been thoroughly established in the soil. Work was also carried on with cotton bollworm,

billbug, cornstalk borer, San José scale, and with methods of controlling flies. Arsenite of soda used for this purpose was found to deteriorate rapidly.

A survey of plant diseases throughout the State was begun. One of the most serious diseases under study was *Physoderma zeæ-maydis* on corn. Attention was also given to the diseases of truck crops, including downy mildew of cucumbers, bean anthracnose, and wilt of cotton and cowpeas.

In the horticultural department work on varieties of apples was continued, as well as on Japanese plums, pruning grapes, breeding tomatoes, muskmelons, and okra, and the investigation of pears.

During the year the equipment of the department of animal industry was increased by a Percheron stallion and a Hereford bull. Breeding work was to be done for the purpose of learning the possibilities of herd improvement by grading up. The value of rice meal and corn meal for hogs was compared in a feeding experiment with rather inconclusive results.

Considerable work was done in the study of selections of awnless barley, the effect of deep planting on the length of hypocotyl of corn, and on variety tests of corn, cotton, wheat, barley, and forage crops. Sudan grass and Fulghum oats were grown at the station with very promising results.

The publications received from this station during the year were as follows: Bulletins 172, Analyses of Commercial Fertilizers; 173, Potash in Mixed Fertilizers; 174, A Little Known Lantern Fly Injuring Corn (*Peregrinus maidis*); 175, The Cotton Root Louse (*Aphis mardi radicis*); Circulars 11, Variety Tests with Cotton, 1912; 12, Silo and Silage Catechism; 13, Soil Building for South Carolina; 14, Rules and Regulations of the South Carolina Crop Pest Commission Governing the Transportation of Nursery Stock—Definition of Nursery Stock; 15, Rules and Regulations of the South Carolina Crop Pest Commission Governing the Transportation of Cotton Seed Originating Outside of Boll Weevil Infested Territory; 16, Rules and Regulations of the South Carolina Crop Pest Commission Governing the Transportation of Materials from Cotton Boll Weevil Territory; 17, Rules and Regulations of the South Carolina Crop Pest Commission Governing the Transportation of Bulbs, Tubers, and Roots; 18, Rules and Regulations of the South Carolina Crop Pest Commission Governing the Transportation of Seeds Other than Cotton; 19, Alfalfa in South Carolina; 20, Gullying and Its Prevention; 21, Peach Culture for South Carolina; 22, Improvement of School Grounds; 23, Controlling Flies; 24, Addresses to the General Assembly on Tick Eradication; 25, Spraying Program for Orchard and Vineyard in South Carolina; and the Annual Report, 1913.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----              | \$15,000.00 |
| United States appropriation, Adams Act-----              | 15,000.00   |
| Farm products, including balance from previous year----- | 2,370.72    |
| Total-----   | 32,370.72   |

The South Carolina station is fortunate in the organization of its substations. They have been well planned for use in permanent rotation and other experiments connected with the projects of the main station, and are also of immediate value to the localities in which they are placed.

#### SOUTH DAKOTA.

*South Dakota Agricultural Experiment Station, Brookings.*

J. W. WILSON, M. S. A., *Director.*

The work of the South Dakota station proceeded without interruption and without any essential change of policy. The new building, costing \$100,000, was erected, furnishing excellent quarters for the director and some of the members of the staff. The old station building was turned over chiefly to the use of the chemical department. M. Fowlds was appointed as assistant in agronomy and E. H. Hungerford took the place of D. E. Bailey, who resigned, as assistant dairyman.

General operations were continued on four substations supported by State funds. The State made an appropriation of \$1,000 for printing popular bulletins. Six sheep of a large tailless breed were obtained from Siberia. These sheep are reputed to be able to live for some weeks from fat stored in the body. The adaptability of the breed to South Dakota conditions will be studied and attempts will be made to secure hybrids between them and other breeds of sheep.

*Adams fund projects.*—Work on selecting and breeding hardy wild fruits of the Northwest for the purpose of improving them and adapting them to commercial conditions was continued. In this study a large number of varieties of plums have been obtained by crossing. Special attention was given to apples, of which many hybrid seedlings were obtained and have been planted. Several instances of graft hybrids of apples were obtained. In one instance the fruit showed the internal character of one parent and the external appearance of the other. Breeding and grafting work was continued with pears. Improved varieties of raspberries and strawberries were obtained and are being distributed throughout the State. Among the ornamentals obtained in breeding experiments several thousand rose seedlings resulting from hybridization are under observation.

The effect of a wide ration, containing an excess of oat straw, upon horses was kept under careful observation. It was found that only a part of the protein of oat straw was digested and the animals apparently drew upon the store of protein in the body for their requirements. Autopsies were made on animals killed during these experiments. Among the diseased conditions found were malnutrition, bone deterioration, navicular disease, spavin, etc.

The investigation of the general problem of rotation in soil fertility brought out some interesting results. The average yield of crops for a period of five years at Brookings was greater where phosphorus alone was used than where any other single element of plant food was used or any combination of fertilizers. Soil analyses showed that even where these results were obtained more than one-half of the applied phosphorus still remained in the soil. In summarizing the five years' work it appeared that phosphorus increased the yield of wheat 38.7 per cent, barley 40.5, corn 25.8, and oats 13. It was concluded that the fertility of the soils in question could be permanently maintained by applying sufficient phosphorus and by including leguminous crops in the rotation in order to return organic matter to the soil.

The study of the morphological causes of difference in vigor of cereals was confined chiefly to the correlations of length of head and weight of grain. A positive correlation between weight of seed and length of head was found in Minnesota Bluestem wheat No. 169. Data were also accumulated on high and low protein of corn and on the conditions necessary for the growth of sweet clover.

The function of ordinary and alkali water in the nutrition of dairy cows yielded some important results. The drinking of alkali water by cows did not produce so-called alkali disease. A slight laxative effect of alkali water was noted at the beginning of the test, but normal conditions were soon resumed. Post-mortem examination and analyses of the vital organs of cows used in this experiment revealed nothing abnormal. The principal material in the alkali water was sodium sulphate, and the most of this was excreted through the kidneys. The kidney excretions were increased as a result of administering alkali water, even when the total amount of water given was somewhat reduced, and the percentage of ash in the kidney excretion was slightly increased. A beginning was made on the study of the rôle of water in the dairy cow's rations. Data are being collected on the income and outgo of water and on the weight and temperature of the cows.

*Work with Hatch and other funds.*—The available Hatch and other funds enabled the station to carry on a considerable variety of experimental work. Variety tests of a large number of fruits and ornamentals were continued; much time was given to the propag-

tion of introduced strains of alfalfa, the object being to secure species or varieties which are particularly adapted to the dry conditions of the western part of the State. In the prosecution of this work the seed of a number of alfalfas with yellow flowers was obtained from Siberia. A machine was devised for transplanting alfalfa, and in cooperative experiments with 1,500 farmers encouraging reports were received regarding the growth of alfalfa from the transplanted seedlings. Thus far appearances indicate that transplanting will prove to be the best method of securing a stand of these strains of alfalfa under dry-land conditions.

Work on sugar beets has involved plat experiments, breeding, field management, ensiling, and production of seed. Such a high percentage of sugar was obtained that in the selection of mother beets for seed production beets with less than 18 per cent of sugar were rejected. The percentage of sugar in beets grown in experimental plats for a series of three years ranged from 16.2 to 22.

The general work in agronomy included a study of grain farming versus stock farming with relation to the fertility of the soil. Corn breeding work was continued in an attempt to modify the oil and protein content. Studies were also made on the effect of disking alfalfa and on the comparative yield of potatoes from planting small pieces and whole tubers. Elaborate variety tests of wheat indicated that in point of yield the varieties range in the following order: Kubanka and Arnautka durum, Bearded Fife, and Bluestem and Beardless Fife. The highest yields of oats at Brookings were secured from Sixty-day, Swedish Select, and North Finnish Black, in the order named.

In a feeding experiment with steers, in which the value of corn silage and mill products was determined, it appeared that good gains were made by all steers on corn silage as a sole roughage. Linseed meal, dried distillers' grains, and cottonseed meal, in the order named, were added to corn silage with economical results. The largest and most uniform gains were made by steers which received linseed meal and corn silage. Corn silage and shelled corn proved not to be a satisfactory ration. For lambs corn silage as the sole ration gave unsatisfactory results. The lambs remained in good health but the gains were too slow. White sweet clover proved to be an excellent roughage when fed with a grain ration for fattening lambs. Pea hay and Siberian alfalfa also gave promising results, while shredded corn fodder seemed not to be satisfactory as a feed for lambs. Preliminary experiments were begun to determine the economy of hogging-off corn and the cost of producing cows.

In a test of milking machines very little difficulty was experienced from a mechanical standpoint in operating these machines. Cows readily adapted themselves to the machines and the milk flow was

apparently not affected. The milk obtained by milking machines was free from sediment and other visible impurities, but contained more bacteria than milk drawn by hand into a partially covered pail. The barn air drawn in by the machine proved an effective source of bacterial contamination. It was therefore recommended that the air be filtered through cotton.

Various methods of cutting and storing ice on the farm were investigated in an attempt to determine the economy of the process and its use in dairying. Various materials and methods of construction are being studied with reference to their suitability for use in silos. Pit silos were studied in different parts of the State and preliminary data collected on such silos indicate that they are giving satisfaction. Records were also continued on the production of the college herd, which has been graded up for seven years from common cows.

The publications received from this station during the year were as follows: Bulletins 142, Sugar-beet Culture in South Dakota—Results to Date; 143, Roughage for Fattening Lambs; 144, Preliminary Report on Milking Machines; 145, A Report of Progress in Soil Fertility Investigations; 146, Some Varieties and Strains of Wheat, and Their Yields in South Dakota; 147, Effect of Alkali Water on Dairy Cows; 148, Corn Silage and Mill Products for Steers—Chemical Analysis of Feeds; 149, Some Varieties and Strains of Oats and Their Yields Per Acre in South Dakota; and 150, Weeds; and the Annual Report, 1912.

The income of the station during the past fiscal year was as follows:

|   |               |
|---|---------------|
| United States appropriation, Hatch Act-----           | \$15,000.00   |
| United States appropriation, Adams Act-----           | 15,000.00     |
| State appropriation -----                             | 17,000.00     |
| Farm products, including balance from previous year-- | 9,593.32      |
| Miscellaneous, including balance from previous year-- | 4,144.14      |
| <br>Total-----  | <br>60,737.46 |

The progress of the South Dakota station was satisfactory as a whole. Both the scientific and practical work of the station are designed to meet the most urgent problems of the agriculture of the State.

#### TENNESSEE.

Tennessee Agricultural Experiment Station, Knoxville.

H. A. MORGAN, B. S. A., *Director.*

The work of the Tennessee station during the year was marked by satisfactory progress in thoroughness and usefulness. No notable changes in the policy of the station occurred. E. C. Cotton resigned as assistant entomologist and was succeeded by H. R. Watts. R. G.

Briggs was appointed assistant horticulturist and placed in direct charge of the horticultural work of the station. A temperature-control plant for use in the study of the effects of high and low temperatures on the activities of the cattle tick has been practically completed.

*Adams fund projects.*—In order to give greater reliability to its results in the study of soil humus the station devoted considerable time to the improvement of analytical methods. The official method for the determination of humus seemed to be unreliable on account of the presence of suspended clay and hydrated iron in the filtrate obtained by the official method of procedure. The modification proposed by the station consists essentially in reducing the  $2\frac{1}{2}$ -gram charge of ammonium carbonate to 1 gram and filtering the entire mixture immediately after adding the carbonate. Contact of the soil with ammonia for one and a half days was found to be sufficient, and gave better results than a shorter period.

Investigations of the factors which influence the lime requirements of soils yielded some interesting results relative to the disappearance of carbonates of calcium and especially magnesium in the soil and the relation of silica to the disappearance of these salts. It was found that excessive amounts of magnesium carbonate were entirely decomposed when left in contact with fallow soils in pots protected from leaching. Three types of soil were used, and applications of chemically pure magnesium carbonate, at the rate of 16,000 pounds per acre, were made in excess of the lime requirement. One year later these soils were found to be strongly alkaline and practically free from carbonates.

Quite conclusive evidence was obtained that magnesium carbonate reacts with silica and is fixed by it, and that calcium may react in the same manner to a less degree. Titanium oxid was also shown to bring about the same decomposition of carbonates. These experiments indicated that any residual carbonate of magnesia in virgin soils is soon decomposed, even under decidedly calcareous conditions, and that magnesium is therefore not to be found in the carbonate form in surface soils. In the further study of soil carbonates the effect of phosphoric acid was carefully investigated. It was found that phosphoric acid is least active of all the available mineral acids upon the organic matter of the soil. Phosphoric acid, however, proved capable of liberating all the carbon dioxid from calcium or magnesium carbonate in soils. It seems possible, therefore, to determine limestone and dolomite, especially if present in a finely ground condition, by means of phosphoric acid.

The study of soil biology met with apparently little success during the year. Apparently no humus was formed by biological action, although considerable loss of organic matter, especially nitrogen, was

noted. The selection of strains of red clover for possible resistance to anthracnose was continued with considerable success. An attempt will now be made to improve the resistant strain of clover along other lines. Similar selection methods were employed in breeding a strain of tomatoes resistant to wilt. In the study of the possible improvement of Lespedeza a large number of types have been selected and are being propagated. Some progress was made in a study of the biology and means of controlling the peach borer.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds a large amount of work was carried on in the various departments of the station. Methods of rotation and soil improvement are being studied with reference to their adaptation to different conditions of the State and to different systems of crops. Particular attention was given to the system of double cropping under Tennessee conditions. On Cumberland Plateau soils fertilizer experiments with potatoes indicated that 179 bushels per acre could be obtained from an application of 12 tons of manure and 600 pounds acid phosphate, as compared with 130 bushels per acre from an application of the same amount of manure without the acid phosphate and 44 bushels per acre with no fertilizer. On this type of soil it was found that if the particular soil be poor in either phosphoric acid or potash it was not economic to apply nitrates until the deficiency in the mineral elements was supplied.

In studies of the Highland Rim soils it appeared that while lime was especially beneficial to clover it was likely to increase the yield of a large variety of crops. Apparently 2 tons of ground limestone per acre was sufficient for a period of five years. Acid phosphate and muriate of potash gave best results when applied before planting. As a cover crop after corn to prevent loss of fertility during the winter, about equally good results were obtained with wheat, rye, crimson clover, and hairy vetch. The study was continued on the amount of drainage water obtained under various experimental conditions and the content of plant food and other elements in the water.

During the year the results of four years of feeding experiments with steers were summarized. These results show that cottonseed-meal rations, from 5 to 7 pounds per day, were as efficient as rations of from 7 to 9 pounds. The gain in weight of steers was higher on the medium than on the large ration of cottonseed meal. On the basis of these experiments it was urged that cattle feeders are not warranted in feeding cottonseed meal to the extent of 5 to 9 pounds per head per day except for periods of 30 to 50 days. Corn silage proved much more effective than cottonseed hulls. The average profit obtained from steers which were fed with cottonseed hulls was \$7.28, and for those which received silage \$11.28.

In studying the effect of cottonseed meal upon hogs it was found that this feed can be safely given to hogs when iron sulphate or some other iron compound is fed with the cottonseed meal at the rate of 1 pound to 50 pounds of the meal. Practical experiments were also carried on which indicated the practicability of the so-called Tennessee wooden-hoop silo.

In pruning experiments with peaches it was demonstrated that when the new growth was pruned before the middle of June the fruiting wood for the succeeding year was produced on the entire length of the branches of the tree, thus making it possible to reduce the height of the tree while providing for a full crop. Other horticultural experiments included the study of the root growth of apple and peach trees as affected by fertilizers and tillage, pruning apple trees, the use of the first crop seed potatoes for second planting; variety tests with sweet corn and sweet potatoes, the management of truck soils, rotations for strawberries, and orchard cover crops. Observations were also made on the injury to vegetation by fumes from a copper smelter as measured by the wood growth in trees. A number of minor experiments were carried on in testing insecticides and fungicides in the control of miscellaneous insect pests and fungus diseases.

The following publications were received from this station during the year: Bulletins 100, Soil Carbonates, a New Method of Determinations; 101, The Rational Improvement of Cumberland Plateau Soils—Conclusions from Six Years of Field Experiments with Various Farm Crops; 102, The Rational Improvement of Highland Rim Soils—Conclusions from Six Years of Field Experiments with Various Farm Crops; 103, The Influence of Ammonium Carbonate upon the Determination of Humus—A Rapid and Efficient Filtration Procedure; 104, Feeding Beef Cattle; and 105, The Tennessee Wooden-hoop Silo; and the Annual Reports, 1911 and 1912.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act | \$15,000.00 |
| United States appropriation, Adams Act | 15,000.00   |
| Farm products                          | 9,622.11    |
| Total                                  | 39,622.11   |

The scientific work of the Tennessee station has yielded results of fundamental importance and wide application, particularly in the study of the chemistry of the soil. Its numerous practical experiments have brought the station into sympathetic contact with the farmers.

**TEXAS.**

*Texas Agricultural Education Station, College Station.*

B. YOUNGBLOOD, M. S., *Director.*

Marked progress was made during the year in the organization of the station work. The personnel and work of the substations were particularly improved and coordinated more closely with the central station. The policy of appointing well-trained men in charge of the substations was adopted. A substation for breeding and feeding has been located on a tract of 600 acres, 430 acres of which belong to the college while 170 acres were purchased for the purpose. A concrete silo and smaller stave silos were erected, and a herd of 600 Angora goats was used in clearing the land. The State legislature provided quite liberally for substations, sheep breeding, and publications. A. H. Leidigh was appointed agronomist in charge of soil improvement at the main station and substations.

*Adams fund projects.*—The investigation of soil problems was pursued actively and resulted in a number of interesting contributions to this field. A study of the ether and chloroform extracts of 28 soils showed the presence of 0.02 per cent ether extract and 0.01 per cent chloroform extract. The ether extract contained 50 per cent unsaponifiable and 40 per cent saponifiable material. The ether extract proved to contain fatty acids and wax alcohols. The investigation of inorganic soil colloids was continued with interesting findings. Colloidal inorganic matter was readily dissolved from the soil by ammonia, the maximum quantity found in soils being 0.59 per cent. The colloidal precipitate was found to contain 47 to 59 per cent silica, 11 to 24 per cent oxid of iron, and 8 to 36 per cent aluminum oxid. Apparently the colloidal material consists of hydrated silica, oxides of iron, and silicate of aluminum with other bases.

In continuing the investigation of digestibility and proximate constituents of feeding stuffs attention was given to ether and chloroform extracts, sugars, starches, and pentosans, as well as to the phosphorus compounds of cottonseed and other matters relating to the project in hand. The principal organic phosphoric acids of cottonseed meal and wheat bran were separated, purified, and analyzed in the form of silver salts. The organic phosphorus compounds of cottonseed meal hydrolyzed by acids were found to yield inosite. The inosite phosphoric acid of wheat bran and cottonseed meal proved to be identical, and the formula  $C_{12}H_{41}P_9O_{42}$  was proposed for this compound. It was found that chloroform removes large percentages of material from hays and fodders which have previously been extracted with ether. The saponifiable material in the chloroform extract was digested to a much greater extent than the unsaponifiable material.

Some difficulty was experienced during the year in finding a sufficiently virulent strain of the virus of infectious anemia. A virulent strain was finally found, however, and was used in infecting a dog from which later a strain of virus pathogenic to mules was obtained. A study is also being made of the possible virulence of this strain for cattle, pigs, rabbits, and other experimental animals. An effort is being put forth to secure protective serum from hyperimmunized animals.

Suitable conditions for the study of inheritance in honeybees were found on the open prairie at a point far removed from other bees. It is believed that work on hybrids can be pursued here without danger of accidental crossing. A number of reciprocal crosses have already been made, and considerable work of an incidental nature has been done in devising means of protecting experimental colonies against enemies.

In continuing work on the hybridization of species of Rubus a large number of hybrids was obtained between Brilliant and Loudon red raspberries and a dewberry. The hybrids showed many of the characters of the raspberry parents, but some of them were sterile. Some hybrids of the second generation came into bearing and showed great variation, and some of the more promising of these hybrids will be selected for further work. The cotton-breeding work was carried on at the station and on various soils in different parts of the State. A large number of varieties have been obtained and are under observation. This material will offer an opportunity for analyzing the results during the coming year.

Numerous difficulties were encountered in securing pure cultures for the further study of nodule formation on alfalfa. The work on blossom-end blight of watermelon has been organized to include an extensive cooperative experiment with the Prairie View Normal College. The large plantings of watermelons thus obtained for experimentation will make possible extensive spraying operations to determine the possible agency of insects in transmitting the disease.

*Work with Hatch and other funds.*—The work carried on under the support of Hatch and other funds was varied and extensive. A uniform plan of rotation of crops and soil improvement was adopted. This plan includes tests of varieties, improvement by selection, studies of the rate and date of seeding, comparison of deep and shallow plowing, and experiments with leguminous cover crops. Numerous tests were made of corn varieties, types of oats, cowpeas, and cotton.

In a comprehensive steer-feeding experiment a ration of cotton-seed meal and silage proved more profitable than the same ration with cottonseed hulls added or with hulls substituted for silage. One ton of cottonseed hulls appeared to be equal to  $1\frac{2}{3}$  tons of silage for

feeding purposes. Upon shipment to market the steers which were fed cottonseed hulls showed the greatest shrinkage.

The work was continued on the crossing of caracul and Shropshire, Lincoln, Hampshire, and Southdown sheep. The purpose of this experiment is to secure, if possible, the production of pelts of high value and a hardy mutton type.

The veterinary department continued its experiments to determine the efficiency of inoculation in the prevention of Texas fever. In these tests several hundred cattle were inoculated without any loss. The efficiency and safety of the method has been greatly improved. A brief survey of the situation in regard to hog cholera was also made.

Experiments were begun with *Vitis champini* as a hardy grape stock for unfavorable soil and weather conditions. Some of the older vines of this species proved exceedingly vigorous during the summer. Experiments were also carried on in the disinfection of nursery stock, particularly for crown gall, a determination of the germinating power of the seed of oak and coniferous trees, and a study of the value and longevity of the so-called Indian peach as a stock for grafting purposes.

The use of cottonseed meal was studied from various standpoints. Preparations made from cottonseed meal and cottonseed flour were tested in seven digestion experiments with men. The digestibility of the protein of cottonseed meal averaged 77 per cent; the digestibility of the fat was high—about 95 per cent. The body requirement of protein was satisfied by 2 ounces of cottonseed meal daily, together with 2 quarts of milk and 8 ounces of corn meal. An elaborate soil survey was continued for the purpose of gaining information as to the physical and chemical composition of the various types of soil throughout the State.

The entomological department gave considerable attention to a study of the life history of the turnip louse. This insect was found to breed viviparously through the winter. A parasite imported from Europe, but not yet widely distributed, was found to affect the turnip louse, the only other natural enemies being ladybird beetles and one species of syrphus fly. Fungus diseases may possibly aid in the control of this pest. Spraying experiments with soap solution showed that these insecticides are effective against the turnip louse. An experiment was begun to determine the effect of various insecticides upon the germination of corn.

Investigations of beekeeping were continued actively. It is found that when the swarming season appears six or seven weeks in advance of the main honey flow, delay of swarming by giving additional room or by destroying queen cells is advisable. Considerable attention was given to methods of fumigating supers and hive bodies

for the destruction of the wax moth and other bee pests. It was found that for this purpose two and two-thirds ounces of carbon bisulphid are required for each 10.6 cubic feet of space. Data were also accumulated on the economics of beekeeping. It appears that the small beekeeper readily finds a good local market for his honey. The major part of the honey produced in Texas is consumed within the State and the information collected by the station indicates that larger quantities of locally-produced honey would be consumed if offered upon the market.

The following publications were received from this station during the year: Bulletins 155, The Ether Extract and the Chloroform Extract of Soils; 156, The Phosphorus Compounds of Cottonseed Meal and Wheat Bran; 157, Hog Cholera and Its Prevention; 158, Investigations Pertaining to Texas Beekeeping; 159, Steer Feeding; 160, Commercial Fertilizers in 1912-13; 161, The Composition of the Soils of South Texas; 162, Composition and Digestibility of the Chloroform Extract of Hays and Fodders; 163, Digestion Experiments on Men with Cottonseed Meal; Circulars 1, Strawberries Under Irrigation in South Texas; 2, Anchoring Houses in Overflow Districts; 3, Truck Farming; 4, The Best Type of Implement Shed for Texas Farms; and the Annual Report, 1912.

The income of the station during the past fiscal year was as follows:

|  |                        |
|--|------------------------|
| United States appropriation, Hatch Act-----              | \$15,000.00            |
| United States appropriation, Adams Act-----              | 15,000.00              |
| State appropriations-----                                | <sup>1</sup> 87,500.00 |
| Individuals, including balance from previous year-----   | 1,397.38               |
| Farm products, including balance from previous year----- | 976.54                 |
| <br>Total-----   | 119,873.92             |

The esprit de corps of the staff of the Texas station is excellent and the results of this loyalty and cooperation are shown in the character of the research work of the station, which is much appreciated in the State.

#### UTAH.

Utah Agricultural Experiment Station, *Logan*.

E. D. BALL, Ph. D., *Director*.

No essential change occurred in the purpose or policy of the work of the station during the year. A new brooding plant was constructed with much better facilities for the continuation of the poultry work. A number of new colony houses were built, two of them on a larger plan than those which had previously been used. These houses will serve for experiments in the longevity tests in breeding

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<sup>1</sup> For two years.

hens. A silo was erected for experiments in testing corn silage. Dr. C. N. Jensen, plant pathologist, resigned and his place was taken by Dr. G. R. Hill.

*Adams fund projects.*—The selecting and mating of fowls for egg production was continued along the line of breeding from poorest, medium, and best layers. In this work careful individual records were kept. A compilation of seven years' records of egg production indicated that at least three years are necessary to furnish a safe basis for judging egg-laying capacity. An additional instance of seasonal variation in egg laying was had during the year. Practically every flock made a low record in contrast with the unusually high record of the preceding year. This seasonal variation could not be accounted for by feeding methods or other features of the management of the hens, and was attributed to the little-understood effects of climatic conditions. Fowls molted unusually late in the season, thus throwing two molting seasons into one cycle of annual production. This may have influenced the total egg yield. One of the station hens completed five years of laying with a record of 816 eggs.

A grasshopper outbreak occurred during the season, thus giving an opportunity to test methods for controlling these pests. An immense swarm of grasshoppers deposited their eggs through a strip of land several miles in length. These egg patches were located and disked in the fall and again in the spring. In one district, at least, the egg masses were entirely destroyed. In all localities where the method was tried it appeared to be effective and economic.

The study was continued on the range of flight and distribution of the sugar-beet leafhopper. It is hoped that it may be possible to gain information which will enable the station to predict outbreaks of this pest. In continuing work on the alfalfa weevil attention was given particularly to the agency of birds in distributing this pest and to its natural powers of migration. Work on the wheat-straw worm was continued, particularly on dry lands.

In a continuation of a study of the effect of arsenical sprays on the life of orchard trees, a new orchard was planted for specific use in this investigation. The solubility of lead arsenate received a great deal of chemical attention. It was found that some virgin soils contain appreciable quantities of arsenic which comes from the decay of the native rocks. Many cultivated orchard soils proved to contain large amounts of arsenic, but no constant relation was observed between the total quantity of arsenic and the water-soluble arsenic in these soils. One soil which contained 100 parts per million of total arsenic contained less water-soluble arsenic than another soil which had only 5 parts per million of total arsenic. Paris green was found to be soluble to four times the extent of arsenate of lead in the soils.

In connection with these investigations, the effect of arsenic upon soil bacteria was studied. It was found that water-soluble arsenic may be present in soils to an extent of 82 parts per million without entirely stopping ammonification and nitrification. Large quantities of ammonia and nitric nitrogen were produced in soils containing 50 parts per million of water-soluble arsenic. No danger was foreseen therefore of the injury to soil bacteria from the ordinary application of arsenicals. The presence of water-soluble arsenic in the soil up to the extent of 10 parts per million stimulated the activity of nitrogen-fixing bacteria. Apparently the stimulation was not due to arsenic acting as a source of energy but rather to its inhibiting action on injurious soil organisms.

In the study of the so-called niter spots it appeared that some of the agricultural soils of Utah contained many times as much nitrate as occurred in normal soils. These soils were found also to contain a high percentage of other alkali salts, and to be characterized by a brown, greasy surface when the accumulations were excessive. Much of the country rock contributing to the formation of these soils proved to be heavily impregnated with nitrate accumulations. From an examination of 58 samples of cretaceous shale it is estimated that the shales exposed from Palisades, Colo., to Emery, Utah, contain about 90,000,000 tons of sodium nitrate.

*Work with Hatch and other funds.*—A large amount of experimental work was carried on with the aid of Hatch and other funds. In the department of agronomy variety tests were made with corn, wheat, potatoes, sugar beets, and alfalfa. Breeding experiments were also carried on in the production of sugar-beet seed and the improvement by selection of potatoes and alfalfa. A comparative test was also begun of the value of forage mixtures and the special study of the relation of soil moisture and soil solution to plant growth. The institution of a system of farm drainage was found by experiment and practical application by farmers to be an efficient means of removing alkali from the soil and for improving its tilth. Variety tests with cereals, root crops, and other forage crops were carried on, not only at the main station, but in cooperation with the farmers in various parts of the State.

From a study of the change in weight in wheat and oats during storage it was found, contrary to popular opinion, that there is a gain of  $2\frac{1}{2}$  to  $4\frac{1}{2}$  per cent during the fall after harvest. These results were obtained in the Cache Valley and are not considered as necessarily true for all localities. In all cases there was a gain in weight during the winter and a loss in summer, but the grain weighed less at thrashing time than at any later period.

In connection with the irrigation work of the station the effect of manure on the water requirement of plants received careful atten-

tion. Much time was devoted also to a study of the irrigation of alfalfa and the movement of moisture in soils under different conditions of treatment. A beginning was made of an investigation of the factors which affect the evaporation of water. All of the common alkali salts were tested in different strengths, both singly and in combination, using different soil types and different crops to determine the relative toxicity of these alkali salts. In these tests sodium chlorid proved most injurious, with sodium nitrate second and sodium carbonate third in toxicity.

Thus far the attempt to influence the production of apples by summer pruning and thinning has given negative results. The experiments were conducted on young trees, however, and it is believed that some effects will be observed when the trees become older. Careful individual records are being kept of the yields of various trees in the experiment. The station work on frost prevention showed that there is a constant difference in minimum temperatures from 5 to 7 degrees between the bench lands and the lower lands of the valleys.

The horticultural department also began a study of the relative development of root and top in young apple trees under varying amounts and times of application of irrigation water. Similar investigations were carried on with peaches. Tests are also being made of the adaptability of hardy varieties of walnuts to various parts of the State. Among the variety tests of miscellaneous fruits particular mention should be made of work on grapes. The Isabella grape has given excellent results in the southern part of the State. The Flame Tokay proved too susceptible to freezing. The results are believed to show the feasibility of a commercial winery in the southern part of the State.

In the study of the relation of blooming periods and yields of fruit to minimum temperatures it was found that frosts of from 4 to 9 degrees when the buds were moist caused less damage than those of similar or greater severity when the buds were dry.

The botanical department began the study of pasture conditions in several districts of the State. The study includes a survey of the weeds, grasses, and other forage plants, the relative value of different combinations, and the advisability of weed removal and reseeding. This study will be extended to the open range. The California peach blight was controlled by summer spraying with Bordeaux mixture. The application did not burn the trees and gave clean fruit. Lime-sulphur used in summer proved to be slightly injurious and less effective. Much attention was also given to a study of the diseases of potatoes and tomatoes. In the breeding of potatoes one variety has shown its superiority in all tests and selected strains of this variety will be distributed for cooperative testing during the coming year.

Some attention was given also to the relation of ventilation to the keeping quality of fruit and vegetables, especially to the effect of an excess of carbon dioxid in refrigerator cars. Among other related lines of work were observations on the ripening of peaches and upon blight of beets.

In a chemical investigation of the milling and baking value of Utah wheats it appeared that the weight of irrigated wheat per hundred kernels was greater than that of either spring or winter dry-farming wheat. The protein content of the irrigated wheat was lower than that of either the spring or winter dry-farming wheat. Flour produced from winter dry-farming wheat had a slightly lower moisture content than that obtained from other kinds of wheat. These investigations, which extended over a period of eight years, demonstrated that the dry-farming wheats in Utah are characterized by low moisture and high protein content.

An elaborate spraying experiment was made on the practical control of the codling moth. It was found that the great majority of the first brood of worms and more than one-half of the second brood enter the fruits in the calyx cups. The second brood of worms was found to be ten times as large as the first. The efficiency of an insecticide method was therefore measured by the extent to which it destroyed the worms of the first brood in the calyx end of the fruit. The first application, driven with force into the calyx cups, proved to be the most valuable of all the insecticide applications, killing approximately 99 per cent of the worms of the first brood.

A comparative study was made of the value of the first, second, and third crop of alfalfa hay for milk production. A quite common belief prevails among farmers in Utah that the second crop of alfalfa is less valuable than the first or third for this purpose. The results of the station's experiments indicated that the second crop of alfalfa hay was equal to either of the other two crops. It seemed to be less palatable to the cows, and on the whole a smaller amount was eaten, but the results show a somewhat greater economy in milk production.

The station awakened considerable interest in cow-testing associations as a result of its investigation of the relative milk capacity of individual cows. From one series of tests it appeared that 48 of the best cows were yielding a greater profit than 189 of the poorest. There appeared to be no correlation between the amount of fat produced during the first month and the record for the year.

The publications received from this station during the year were as follows: Bulletins 123, Farm Drainage—A Manual of Instruction; 124, Fruit Variety Tests on the Southern Utah Experiment Farm; 125, The Chemical Milling and Baking Value of Utah Wheats; 126, A Comparison of First, Second, and Third Crop Alfalfa Hay for Milk Production; 127, Report of the Richmond-

Lewiston Cow Testing Association; 128, Blooming Periods and Yields of Fruit in Relation to Minimum Temperatures; 129, Codling Moth Studies in 1911—The Driving Spray Under Excessively Wormy Conditions; 130, The Change in Weight of Grain in Arid Regions During Storage; and 131, Variety Tests of Field Crops in Utah; Circulars 12, Thinning Apples; 13, Fruit for Exhibition; 14, Housing Farm Poultry; 15, Pastures and Pasture Grasses for Utah; and 16, Better Seed.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----    | \$15,000.00 |
| United States appropriation, Adams Act-----    | 15,000.00   |
| State appropriation-----                       | 18,058.54   |
| Farm products-----                             | 2,360.94    |
| Balance from previous year, miscellaneous----- | 712.54      |
| Total-----                                     | 51,132.02   |

The work of the Utah station progressed without interruption, and its investigations are producing tangible effects in the development of agricultural industries.

#### VERMONT.

Vermont Agricultural Experiment Station, *Burlington*.

J. L. HILLS, Sc. D., *Director*.

A rearrangement of the relations between the station and other State agencies concerned in agricultural work was made during the year, with the result that the station was definitely relieved of all extension work, while retaining harmonious relations with other State institutions. G. F. Anderson was made assistant chemist, W. C. Stone assistant horticulturist, and F. C. Fiske assistant plant pathologist. The additions to the equipment of the station were of minor importance, consisting of a greenhouse for use in plant pathology and a few pieces of scientific apparatus.

*Adams fund projects.*—The investigations of the storage of sugars and other carbohydrates in the maple was continued. A number of small trees were girdled for the purpose of introducing an artificial factor which might assist in interpreting data already collected. It was found that the maple trees carried more sucrose the colder the weather. The moisture content above and below the girdle was found to be quite different. An attempt is being made to learn where the sugar is stored in the tree. In the analytical work the tree is reduced to sawdust and analysis made from different parts of the tree. The work has also been extended to other species of trees.

The nutritive value of milk is studied in connection with feeding experiments with 162 young pigs. Exhaustive chemical studies were

made a part of this investigation, but the mass of data thus obtained has not yet been digested.

The influence on plant growth of an excessive amount of carbon dioxid was studied, particularly on beans, peas, and potatoes. Observations were also made on the effect of carbon dioxid in forcing cyclamen and nasturtium for flower production and upon strawberries for fruit production. The gas was found to have a decided stimulating effect upon the growth of various crops. Carbohydrates in the tubers and other parts of the plant appeared to be considerably increased by treatment with carbon dioxid, but the protein was less affected. In these experiments the amount of excess carbon dioxid used has been carefully measured. The effect of carbon dioxid upon other plants in addition to those mentioned was investigated with reference to the physiological and chemical effect of the gas.

Distinct advantages were found to follow the use of heavy or large seed. With the sweet pea an earlier blossoming was secured, with Hubbard squash and sweet pumpkin a greater weight of ripe fruit, with lettuce an increased weight of edible, mature leaves and better heading, as well as increased earliness, with spinach a greater weight of leaves, with parsley earlier development of foliage, with radishes larger roots, with beans and various other garden vegetables an increase in size.

Bordeaux mixture was studied both with reference to its fungicidal effect and its stimulating action upon plant growth. It appeared that its fungicidal effect takes place immediately after it is applied, the spores of fungi being prevented from germinating, or the hyphæ being shorter and abnormal if they germinate at all. The apparent stimulating effect of Bordeaux mixture was extremely small. On potatoes the effect of Bordeaux mixture was to diminish transpiration and to lengthen the season of growth. Most of the supposed stimulating effect of Bordeaux mixture is believed to be attributable to the reduction of tip burn and injury from flea-beetles.

Potato scab was found to be due to an organism known as *Actinomyces chromogens*, which occurs in practically all soils and is apparently distributed more through manure and humus than through scabby potatoes. The organism does not thrive in the presence of an acid. The most hopeful method of attack appeared, therefore, to be the use of flowers of sulphur or to attempt to change the neutrality or slight alkalinity of the soil to a weak acid reaction. No varieties of potatoes were found wholly resistant to scab. Ammonium sulphate giving an acid reaction appeared to exercise a preventive action upon the scab disease.

The study of the resistance of potatoes to disease showed that in the case of early blight the varieties which were most resistant were, with few exceptions, of foreign origin, the exceptions being American

varieties without commercial value. The foreign varieties, almost without exception, had no commercial value, being poor in quality and light in yield. The matter of resistance to early blight appeared, therefore, to be an academic rather than a practical problem. None of the varieties of potatoes studied at the Vermont station showed strongly marked resistance to scab.

In a further study of damping off or Fusarium disease of asters and other plants no success was had in producing the disease in asters by inoculation. Positive results were obtained, however, with sweet peas and field peas. Susceptibility to the disease appeared to be increased by too close planting and unfavorable climatic conditions. The exact influence of climatic factors upon this disease is being investigated.

The study of tolerance in New England forest trees was confined chiefly to the white pine. It was shown that plants normally reached the maximum water loss in the morning. If, however, conditions for transpiration were decidedly favorable in the afternoon the maximum loss of water occurred later in the day. The effect of half shade upon the loss of water by seedling white pines was much greater than that upon evaporation apparatus. With the seedling white pine, half shade reduced the amount of transpiration from 48 to 75 per cent.

It was found that damping off could be controlled in white-pine seedlings by the use of formaldehyde or solutions of sulphuric acid. In controlling the disease it appeared advisable to plant the seed less than one-half inch deep in sandy soils and to furnish no shade for the seedling unless the seed was sown late in the season during dry weather. After the period of germination, shade was found to hinder the development of the seedlings. In the comparison of shade and no shade for white-pine seedlings chemical analyses were made of the seedlings. A great variation was found in the nitrogen, total ash contents, and dry weight of the seedlings from different beds.

Work was begun on a study of natural hybridization and the possible origin of species by this means in the case of blackberries and violets, the specific question being whether species can originate by hybridization. Crosses were made with blackberries and the fruit secured and its characteristics recorded. Cytological studies were carried on with violets.

In the investigation of the effect of different amounts of protein in rations for cows the eighth year of work was completed. The data are being computed and analyzed for publication. It is expected that further experiments will be made with a smaller number of cows and a lower protein diet than any previously tested. Work was continued on the study of maintenance rations for dairy cows,

particular attention being devoted to maintenance ration of cows when losing weight and when gaining.

*Work with Hatch and other funds.*—Under the support of Hatch and other funds a considerable variety of experimental work was carried on. The effect of thinning upon the new growth of forest plantings was tested upon experimental plats. This test was extended also to vines and small plants in order to note the change due to increased light and evaporation. The purpose of these experiments is chiefly to ascertain the best conditions for the reproduction of white pine. Similar studies were made on Vermont hardwoods during which much interesting information was collected concerning the economics and outlook for forest plantings and timber utilization in the State.

The chemical department developed a laboratory method for determining the lime requirement of soils, and also a procedure for separating organic ammoniates from the mineral portion of commercial fertilizers. The work of routine inspection and analysis of commercial fertilizers and feeding stuffs was heavy and extensive, as has heretofore been the case. The station also has officially to inspect dairy glassware and the licensing of creamery operators.

The horticultural department studied the problems of apple storage in Vermont, particularly to learn the effect of different packing materials. Hardwood sawdust appeared to be quite satisfactory and did not affect the flavor of the fruit. It helped to regulate the temperature surrounding the fruit. The flavor of the fruit was well preserved by dipping in copper sulphate and Bordeaux. Good results were obtained from packing in hardwood sawdust treated with Bordeaux mixture.

A rather elaborate series of experiments in hand pollinating and self-fertilizing squash was carried on in which some of the plants were left to be fertilized by bees. By means of selections and with the aid of pruning and budding, an attempt will be made to prevent the setting of the small blossoms which produce the small squashes. Similar work was carried on with strawberries and some pedigree records were made upon apples. The persistence of fungus spores through the winter was studied. The brown rot of the plum was found capable of living over for two winters. Various other fungi in cultures withstood the cold satisfactorily.

Environmental influence upon the potato was found to persist through several generations. In this work eight varieties of potatoes were studied through six seasons and three additional varieties through five seasons. The evidence indicated that northern-grown seed is superior to that grown in the South, that the effect of one year's removal of the potato from northern influence is noticeable in

a rapid decline in yield, and that, except in northern latitudes, an occasional change of seed is desirable. The fungus cause of club root of cabbage was shown to make its entrance into the root either through the epidermis or root hairs, from which it spreads from cell to cell, particularly in the cortex; but it always occurred to some extent in the central cylinder. The process of infection is marked by the formation of numerous nucleoli, and the starch disappears during the growth of the fungus.

Experiments with methylene blue in the treatment of abortion in cows were repeated and the method of treatment somewhat modified. The results seemed fully to justify the original conclusions that methylene blue tends to check and to prevent the development of the disease. Methylene blue was administered in amounts varying from 5 to 60 grams to four different herds in which abortion had occurred and in which the agglutination test showed the presence of the bacillus of abortion. In all, 92 cows were thus treated and only one of the animals has aborted since treatment.

The publications received from this station during the year were as follows: Bulletins 168, Investigations of the Potato Fungus *Phytophthora infestans*; 169, Cultural Studies on the Montreal Market Muskmelon; 170, "Mony Meikles Mak a Muckle"—Studies of the Rennet Coagulation of Milk—The Control of the Moisture Content of Butter; A Bacterial Infection of Condensed Milk; The Value of the Escutcheon in Judging Dairy Cattle; Mock Silage; Concerning Certain Pasture Weeds; Moss as a Pasture Weed—The Ensiling of Weeds—The Effect of Hot Water and of Mechanical Treatment on Seeds During Germination—Seed Analyses; 171, Commercial Feeding Stuffs—Concerning the Vermont Hay Crop; 172, Place-effect Influence on Seed Potatoes; 173, Commercial Fertilizers—The Principles of Land Drainage; and 174, Methylene Blue—A Remedy for Infectious Abortion.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act | \$15,000.00 |
| United States appropriation, Adams Act | 15,000.00   |
| State appropriation                    | 1,000.00    |
| Fees                                   | 4,318.73    |
| Total                                  | 35,318.73   |

The research work of the Vermont station is of high grade. With the further relief in prospect from the inspection, from some of the routine analyses, and with the organization of the extension work in the special service for that purpose the station will be in position to make its work more effective than ever before in contributing to the fundamental knowledge of agriculture in Vermont.

## VIRGINIA.

Virginia Agricultural Experiment Station, Blacksburg.

S. W. FLETCHER, PH. D., *Director.*

Conditions at the Virginia station were very unsettled during the year. Changes were made in the personnel which in extent were without parallel, and affected an important part of the station staff. These, with the uncertainty as to the policy to be pursued toward the station in matters of organization and administration, caused a general feeling of unrest, which has not been allayed. Early in the year Dr. N. S. Mayo, in charge of animal husbandry and veterinary work, was summarily removed for reasons not clearly defined as in the interest of the station work, and later Dr. E. B. Fred, bacteriologist, voluntarily resigned to accept a position elsewhere. In the spring of 1914 Dr. S. W. Fletcher, who had been director of the station since 1908, was requested to resign on the ground that he did not fit into the contemplated plans for reorganization, and later Lyman Carrier, agronomist, and W. K. Brainerd, dairyman, were requested to resign or were replaced. W. J. Schoene, State entomologist, was placed in temporary charge as acting director. The station veterinary work was discontinued, the departments of plant pathology and bacteriology were merged, and new men were appointed to look after most of the other lines.

The effects of such radical changes are far-reaching, and strike at the foundations of effective management. The contemplated plan of uniting the administration of the experiment station and the extension division, to which several of the changes were ascribed, was not in accord with the plan the department has urged in other States, and ultimately was not put into effect. For the present no apparent advantage has resulted to the station from these changes, and the lack of a clearly defined policy aimed at the best interests of the station has resulted in bringing about a period of uncertainty.

*Adams fund projects.*—The study of bud formation and the influences which affect this process was conducted both at the station and at one branch station. The effect of summer, winter, and early spring pruning, girdling, and cutting out strips was investigated on dwarf stock. Winter pruning apparently stimulated wood growth and prevented bud formation to some extent. Considerable attention was also given to the effect of moisture as modified by cultivation and irrigation, sod mulch, and different kinds of fertilizers upon bud formation with three varieties each of apple and peach.

The experiments covered about 40 acres of orchards in all. In each orchard under experiment three systems of soil management were followed designed to obtain a high percentage of moisture or to represent commercial practice or to maintain a low-moisture content.

The breeding of apples for the purpose of obtaining late blooming varieties was continued under favorable conditions. Cross pollination was carried on extensively and characteristics of some of the seedlings were carefully studied. It is still uncertain whether the character of late blooming can be made hereditary.

The results of three years' experiments, including the digestion tests, were brought together on the study of the protein and energy requirement for milk production. This investigation was conducted on three groups of pure-bred Holstein cows especially selected for the purpose. Each group received a basal ration of the same relative amount of grain and roughage, but one group received in addition a high-protein ration and a second group a low-protein ration. A second feature of the experiment includes a feeding experiment designed to test the physiological effect of feeding excessive amounts of protein for 10 years or more.

The effect of green manuring on soil has been under study for two years. The green material when incorporated in soils was found to increase the bacteriological count in greenhouses but not under field conditions. In continuing its work on the fixation of phosphoric acid, the station has made use of five of the principal types of soil in Virginia. The study of pasture management has been carried on for five years. Little benefit was noted from disking or harrowing blue-grass sod. Heavy grazing appeared to induce an evenness and density of blue-grass sod. Little advantage was found in grazing cattle in different fields alternately as compared with continuous grazing on the same field.

The study of the relation of parasitic fungi and bacteria to their host plants yielded some interesting results. In a case of the bitter rot of apples the alkalinity in the culture solutions proved to be due to an unbalancing of the nutrients in the solution. Ammonia was also formed. The juice of decayed apples was found to contain less acid than the original apple.

A systematic study of cedar rust of apples showed the general prevalence and seriousness of this disease. The time and amount of infection of apple foliage to cedar rust appeared to depend largely on climatic conditions, an alternation of rain and fair weather being most favorable for heavy infection and a resulting epidemic of cedar rust. The apple leaf was found to be susceptible only during its early stages of growth. Certain varieties, like Winesaps and Arkansas were found to be practically immune, while York Imperial and Northern Spy were very susceptible. Copper-lime-sulphur spray proved quite efficient as a preventive of the disease if applied soon after the young leaves unfold, but the destruction of all cedar trees within half a mile of the orchard is recommended as the most efficient means of controlling cedar rust.

In the investigation of nitrogen fixation work was done on 80 soils collected during the soil survey of the State. Cultivated soils were found to fix more nitrogen than virgin soils and to exhibit a higher nitrifying power. In the clay soils sand appeared to increase nitrification as much as did lime.

*Work with Hatch and other funds.*—All departments of the station carried on experimental work under the support of Hatch and other funds. The chemical department continued its studies of the associative effect of leguminous and nonleguminous plants. Data were also collected on the effect of a long-time crop rotation upon soil fertility.

The immediate effect upon yield obtained by crossing different strains of corn was found to be so marked that the farmer was recommended to secure pure-bred seed corn of the same variety as his own, but not closely related to it, and mix the seed before planting. The increase in yield by crossing pure-bred seed of the same variety amounted in some cases to 30 per cent. In growing alfalfa August seeding was found to be preferable to spring seeding. Acid phosphate and basic slag gave more marked results than any other fertilizer on alfalfa. Lime was found to be the best fertilizer for the growth of alfalfa in many of the soils.

A number of fertilizer tests were made with tobacco. When lime was used on heavily fertilized tobacco it appeared to have the tendency to make the leaves and plant rather coarse, but to increase the yields. The yield of different varieties of tobacco under experiment varied from 950 to 1,600 pounds. The experiments of the horticultural department included a study of the laws of inheritance in various garden vegetables, the relation between the application of mineral fertilizers and the prevalence of fire blight, variety tests of fruits, spraying for insects and fungus diseases, and the use of cover crops. The results from fertilizer experiments on apple trees were indefinite and hard to interpret. Nitrogenous fertilizers, in addition to sod mulch, showed a decided increase in the yield of apples.

Experiments on the tomato blight indicated that the red cherry tomatoes are practically immune to this disease, but have no commercial value. A few commercial varieties were found to be partly immune to the disease. The work involves 27 strains or crosses of tomatoes planted upon 2 acres of ground. A plant-disease survey of the State is under way.

Among other operations of the station mention may be made of a study of the relation of temperature to the acidity produced by certain milk bacteria, a study of the leaf spot of spinach, methods of making ice cream, forage crops for hogs, and wintering steers, and miscellaneous fertilizer and cultural experiments carried on at the county experiment stations.

The publications received from this station during the year were as follows: Bulletins 202, The Immediate Effect on Yield of Crossing Strains of Corn; 203, Experiments on the Control of the Cedar Rust of Apples; 204, The Management of Blue-grass Pastures; and the Annual Reports, 1911-12.

The income of the station during the past fiscal year was as follows:

|   |             |
|---|-------------|
| United States appropriation, Hatch Act----- | \$15,000.00 |
| United States appropriation, Adams Act----- | 15,000.00   |
| State appropriation-----                    | 21,250.00   |
| Farm products-----                          | 3,226.52    |
| Miscellaneous -----                         | 1,022.40    |
| Balance from previous year-----             | 2,298.48    |
| <hr/>                                       |             |
| Total-----                                  | 57,797.40   |

The work of the Virginia station has been well organized and efficiently manned in the past few years. Its research work has been placed on a high plane, and much success has been met with in developing the branch stations and farms in different parts of the State so as to furnish a means of extending the experimental work of the station to various localities and branches of agriculture. A great field for usefulness is open to it, provided tranquil conditions can be restored and maintained and the necessary support provided for uninterrupted work.

#### Virginia Truck Experiment Station, Norfolk.

T. C. JOHNSON, B. S. A., M. A., *Director.*

The activities of the Virginia Truck Experiment Station during the year resulted in the accumulation of definite information on a number of problems connected with the culture and management of truck crops and added greatly to an understanding of methods which are necessary to successful truck farming in Virginia. An office building was erected at a cost of \$2,500. During the year the State crop-pest commission detailed one of its workers to study garden insects in connection with the station.

A carefully conducted experiment was carried on with fertilizers for kale in connection with a study of the effects of various systems of rotation upon the yield of kale. On the experimental plats the yield of kale following a rotation of tomatoes, beans, and millet was 50.65 pounds, following potatoes and corn 39.05 pounds, following crimson clover after potatoes 61.81 pounds, following crimson clover with lime 93.46 pounds, on a plat receiving lime and stable manure 110.67 pounds. By the use of lime the efficiency of crimson clover as a soil improver was increased 51 per cent. The expenditure of \$5.37 for clover seed and lime brought a heavier yield than the expenditure of \$30 for stable manure. The experiment indicated the requirement of lime and humus for the best growth of kale.

Miscellaneous notes were recorded on the culture and management of practically all of the various truck crops grown in the region of Norfolk, and also upon the most economic and satisfactory methods of home canning as shown by the experiments at the station.

In a study of the phosphate requirement for spinach the use of 362 pounds of 16 per cent phosphoric acid per acre produced a yield 37 per cent greater than the application of 144 pounds of the same grade of phosphate per acre. It was recommended on the basis of this experiment that fertilizers for spinach contain a higher percentage of phosphorus than was found in the ordinary brands.

In the control of the green-pea aphis good results were obtained from whale-oil soap alone or combined with nicotin sulphate. The results obtained in this work indicate the advisability of spraying one or two days after the aphis first appears and a second time about one week later if necessary. It was also found desirable not to grow crimson clover in the vicinity of the pea field.

The following publications were received from this station during the year: Bulletins 9, Kale Fertilizers; and 10, The Home Vegetable Garden.

The station received a State appropriation of \$5,000 and also \$5,000 from the State board of agriculture.

#### WASHINGTON.

*Washington Agricultural Experiment Station, Pullman.*

I. D. CARDIFF, Ph. D., *Director.*

For the purpose of facilitating the administrative work of the station two changes were made in organization. The divisions of animal husbandry, crop production, dairying, and soil physics were placed under one administrative head. The division of plant pathology was abolished and a division of botany organized with the botanist as head, and a plant pathologist, two assistant pathologists, and one assistant bacteriologist on the staff. A number of changes occurred in the staff. Among the resignations were P. J. White, agronomist; Alex Carlyle, cerealist; Robert Ashby, animal husbandman; and J. G. Hall, plant pathologist. William Hyslop was appointed animal husbandman and E. G. Schafer agronomist. The State legislature established a bureau of farm development, of which the director of the station is ex officio in charge.

*Adams fund projects.*—Considerable progress was made in the study of sulphur as plant food. It was found that colloidal silicates interfere with the necessary determinations, making their removal necessary. It was also found to be essential that all chemicals be tested for their freedom from sulphur. The work was carried on in greenhouses with wheat, barley, vetch, and peas. Wheat proved to

be decidedly influenced by the sulphur content of the soil. Some of the cultivated soils gave evidence of having lost 50 per cent of their sulphur.

The chemical study of the progressive development of the wheat kernel reached the point where a cytologist seemed to be necessary to interpret the results more accurately. An attempt will be made to determine by cytological examination of the grain, from its youngest stage to maturity, at what time the starch and proteins are laid down, and in what order. The study of the translocation of starch and nitrogen indicated that starch may be translocated at lower temperatures than nitrogen. The grain did not fill out properly when the moisture content fell below 40 per cent.

A beginning was made on the study of the baking qualities of flour, in which the importance of the different compounds of flour are to be determined by segregation of these compounds and the preparation of synthetic flours. It was found possible to increase the nitrogen content of wheat as much by cultivation as has been sometimes attributed to climatic influences. The extremes of variation were not so marked in the case of spring wheat. The effect of soils and soil management on the quality of wheat is being investigated at the main station and two or three other localities in the State. This study includes a determination of the effect of water upon the chemical composition of wheat.

On account of inadequate facilities for rearing parasites little progress was made in the study of the interaction between parasites and their insect hosts. Numerous preparations were made of normal and parasitized plant lice, and a cytological study will be conducted on this material. Some progress was also made on the bud weevil. In the study of the progressive immunity of insects to insecticides, evidence was obtained of a decided reaction of this sort in certain insects. Much attention was given to the life history, habits of hibernation, and other matters connected with the economic importance of ground squirrels.

From tomato plants affected with blight two species of *Fusarium* were isolated, *F. orthoceras* and *F. oxysporum*. The disease was reproduced by inoculation in the roots, thus indicating their causal connection with the disease. The fungi were found to be characterized by high-temperature requirement for optimum growth. Plants exposed to intense sunlight and wind were made more susceptible to the disease. On account of the presence of the fungi in the soil and underground plant material it has proved difficult to devise a practical method of soil disinfection. Crop rotation proved to be of doubtful value in controlling the disease.

In a study of soil moisture in Washington soils crops have been grown in large tanks since 1911. About  $3\frac{1}{2}$  acres of land was de-

voted to parallel experiments to check the results obtained in the tanks. In these plats the moisture was determined for each foot to a depth of 10 feet. The water required to produce a unit of dry matter in any given plant was found to vary widely. Incidentally the position of nitrates in the soil was found to vary according to the moisture movements. In the early spring the nitrates were found to have been leached down to the third foot as a result of the winter rains.

About 3,000 raspberry and blackberry hybrids came into fruit during the year, and the fruit characters of these hybrids were studied and recorded. An attempt is being made to determine why the loganberries and red and black cap raspberries do not show a splitting of their characteristics in the second and subsequent generations. Progress was also made in the study of the winter drying of apple trees, which results in a trouble known as rosette. Histological studies were made of the abnormal tissues of these trees. It appeared that the injury was due to winter drying, but apparently some evidence was obtained that the trouble can be transmitted through buds, which would indicate the presence of a disease.

The study of red-water in cattle brought forth evidence that this is a specific disease quite common in the western part of Washington. The disease is characterized by a chronic course with characteristic lesions on the mucous membrane of the bladder and bloody kidney excretions. The cause of the disease was not discovered. It was shown that the blood of sick animals does not carry the causative organism, but that inoculation may be made with tissue from the bladder lesions of infected cattle. Natural recovery from the disease apparently does not take place, and remedies thus far tried have shown poor results.

*Work with Hatch and other funds.*—The work carried on with the aid of Hatch and other funds was largely in the departments of botany, chemistry, entomology, farm crops, and horticulture. Considerable attention was given to the diseases commonly observed on miscellaneous field, garden, and fruit crops, and special study was made of wheat smut. The best seed treatment for this trouble was found in a solution of 1 pound each of copper sulphate and sodium chlorid in 5 gallons of water, the seed to be immersed for 10 minutes. In this work it was incidentally found that ordinary commercial thrashing mechanically destroys the vitality of nearly 30 per cent of the seed. It was also shown that about half of the smut infection is carried over in the soil rather than upon the seed. An unusual number of fires and explosions in thrashing apparatus throughout the State led to a study of this matter, in which it was found that smuts were largely the cause of the trouble.

A survey was made of the food plants used by sheep upon the Mica Mountain. In that region it appeared that brush and shrubby plants were more important for sheep than grass and herbs, the principal food plant being buckbush in the yellow-pine forest and huckleberry in the white-pine forest. Evidence was obtained that sheep well managed do not have any deleterious effect upon the development of the forest or its forage plants.

The possibility of the modification of the chemical composition of wheat by line selection was rather thoroughly studied. The results of this work indicate that high and low nitrogen content is not a property of wheat which can be fixed by line selection. The chemical composition of wheat appeared to be largely a matter of environmental influence. This work has been carried on for a number of years, and the results indicate that further attempts to improve the chemical composition of Washington wheats by line selection should be abandoned.

The Colorado potato beetle recently became firmly established in the State of Washington. A series of experiments were undertaken in the control of this pest. It was found that in Washington there are two broods of beetles during the season, the maximum of the first brood occurring during the last week of June. Satisfactory results in controlling the pest were obtained with either Paris green, arsenate of lead, or arsenite of zinc. In attempts to control root maggot, it was found that naphthalene was injurious to cabbage plants, and further experiments will be devised to learn some more practical remedy for these insects.

A large amount of energy is being expended in variety testing of cereals, peas, corn, soy beans, sorghums, millet, flax, and buckwheat. In connection with this work ear-to-row tests with corn are being carried on and studies on inheritance in oats and barley. A few apparent mutants have been observed in oats and also some natural hybrids. In all of this work in breeding and selection, the appearance of any particularly valuable strain is made the basis of further breeding to obtain improved seed for distribution throughout the State.

A study of apple pollination was conducted in the Spokane Valley. In this work records were made of the varieties which are commonly self-sterile and of the best means of securing proper fertilization of these varieties. The effect of irrigation on the storage of apples was studied in cooperation with orchardists and a cold-storage plant at North Yakima. It appeared that fruits from trees which had received an excess of water showed poor keeping qualities, the tissue being soft and easily broken down. The best results in storage were obtained with medium-sized fruit developed on trees which received a medium amount of water. Some work was also conducted on frost prevention

as well as upon the value of winter spraying, orchard cover crops, and methods of pruning.

The following publications were received from this station during the year: Bulletins 111, A Report of the Investigations Concerning the Chemical Composition of Wheat, 1906 to 1912, inclusive; 112, A Preliminary Report on the Investigation of Bovine Redwater (Cystic Hematuria) in Washington; 113, Plants Used for Food by Sheep on the Mica Mountain Summer Range; Popular Bulletins 53, Cause of Variation in Per Cent of Fat on Market Cream from Farm Separators; 54, Preserving Eggs; 55, Cleanliness and Cold as Applied to the Dairy; 56, "Fire Blight" of Pear and Apple; 57, Prune Growing in Southwestern Washington; 58, Sheep for Washington Farms; 59, Spraying Calendar for 1914; 60, Corn Growing in Washington; 61, The Peach Twig-borer; 62, Potato Growing in Washington; 64, Winter Sprays: Sulphur-lime Wash and Crude Oil Emulsions; 65, "Fire Blight"; 67, Top Grafting of Fruit Trees; 68, Report on Chemical Composition of Wheat; 69, Dry Farming in Washington.

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Hatch Act-----              | \$15,000.00 |
| United States appropriation, Adams Act-----              | 15,000.00   |
| State appropriation-----                                 | 41,529.16   |
| Fees, including balance from previous year-----          | 464.42      |
| Farm products, including balance from previous year----- | 3,132.45    |
| Miscellaneous -----                                      | 494.51      |
| Total-----   | 75,620.54   |

The work of the Washington station is particularly strong in plant physiology, the selection of plants, the study of the modification of chemical composition under various influences, and the plant food of soils.

#### WEST VIRGINIA.

**West Virginia Agricultural Experiment Station, Morgantown.**

E. D. SANDERSON, B. S. A., *Director.*

Some readjustment was brought about between the work of the college and station. The burdens imposed on the men employed both in the college and station had become heavy and the rearrangement made conditions in this respect somewhat more satisfactory. Additional land is needed for strictly experimental purposes in agronomy and animal husbandry, for the reason that much of the farm is now devoted to commercial market gardening. An effort is being made to secure land for this purpose and also substations in suitable localities in different parts of the State. F. E. Bear was placed in charge of soil investigations and E. W. Sheets in charge of animal industry.

*Adams fund projects.*—The study of factors affecting the weight, composition, and hatchability of eggs yielded some interesting results. It was found that the average weight of eggs varies from month to month, reaching the maximum in the early spring when the fowls are heaviest and laying most freely. White Leghorn eggs were found not to reach the maximum weight until the hens were in their third laying season. The size and number of eggs were reduced by scanty feeding and increased by liberal feeding. Eggs from fowls poorly fed proved not to hatch to such a high percentage as did those from fowls fed more liberally. It was found that the weight of eggs was reduced when a ration was fed in which the necessary nutritive constituents were not present in proper proportion. An attempt is also being made to devise a method for determining the vitality of the egg germ by measuring the amount of carbon dioxid given off during incubation.

Previous work on acidity of soils had not led to any significant results. The project on that subject was modified, and a study will be made of minimum lime requirements of soils and the effect of varying amounts of lime on crop yields. Continued studies on the pollination of apples show that Rome and York Imperial apples are practically self-sterile. These studies were made on trees inclosed in cages. Frost proved to be more injurious inside the cages than on unprotected trees in the field. A special study is being made of the vitality of pollen of different strains of trees, and new facilities furnished by improvements in the horticultural building will offer better opportunity to continue this work.

Distinct progress was made in studies of the relation of weather conditions to transport and virulence of apple rust and of the physiological effect of the rust on the tree.

In the further study of cucumber mildew a method was devised for growing plants under aseptic conditions and thus securing sterile cucumber tissue upon which cultures of the fungus could be made. Work on apple rust progressed satisfactorily. It was shown that climatic conditions have much to do with infection from this disease and that the disease may be controlled by spraying at the proper time. For the permanent eradication of the disease, however, it was found necessary to destroy neighboring cedar trees. In the investigation of the physiological effect of pruning apple trees, an analytical examination was begun of the tissues of trees pruned in different manner in order to determine the effect of pruning upon the cell sap and plant food.

In applying pressure by means of special apparatus it was found possible to destroyenzyms. Studies were continued on the effect of high pressures upon bacteria and other organisms. Yeast was destroyed by pressure of 60,000 pounds per square inch for 1 hour.

Apple juice was rendered sterile by pressure of 60,000 to 80,000 pounds for 30 minutes. Peaches and pears required no more severe conditions to produce sterility. Blackberries, raspberries, tomatoes, and various garden vegetables apparently could not be rendered sterile by pressure. Most of the samples ultimately fermented or spoiled. No trouble was experienced in preserving peaches in a sterile condition by means of pressure. Experiments with pure cultures of various organisms indicated the exact amount of pressure and time required to destroy these organisms. A considerable variation was noted in the time and pressure required for sterilizing *Bacillus prodigiosus*, *Streptococcus lacticus*, several species of yeast, and the bacilli of typhoid and diphtheria. It is believed that the method of pressure may be applicable for use in sterilizing culture media, thus obviating the disadvantages of changes brought about by sterilizing media by means of heat.

Some interesting results were obtained from the study of the relation of temperature to the development of insects. It appeared that the rate of insect development is affected by temperature, the rate increasing in direct proportion to the increase in temperature within the normal limits of development. It was also found that the effective temperature for conditions of ordinary variable temperature is higher than the mean for the whole period. In this work a new temperature chamber was built, which will render more accurate the control of temperature in this work.

*Work with Hatch and other funds.*—The work carried on by the station with the support of Hatch and other funds was of considerable extent and variety. The continuation of experiments on the soil-fertility plats indicated the need of phosphorus and the requirement of lime. In this work 24 varieties of soy beans were used upon which some hybridization experiments were also conducted. The work on the soil-fertility plats also included tests of wheat, corn, oats, and other forage crops. A study of methods of pasture treatment was also begun.

Experimental feeding of beef cattle was begun on an extensive scale in order to determine the relative effect of feeding in the open field and sheds through the winter and for the purpose of comparing the effects of corn silage with native hay. Other experiments involved the feeding of breeding ewes and the improvement of sheep by crossing. A preliminary survey of the live-stock industry of the State was also made.

In the chemical department the usual amount of analytical work was done. This included analyses of fertilizers, samples of limestone, and determinations of the lime requirements of soils. The dairy department made a study of the sanitary conditions and methods of management of dairies surrounding two cities.

Experiments on the control of green-apple aphid indicated that the best treatment for this insect is the application of the lime-sulphur mixture in winter to kill the eggs. Insecticide methods were also tested with apple and peach borers and corn-ear worm. A comparative test was carried out to gain information on the relative effect of arsenate of lead applied as a powder and as a liquid.

The department of farm management in cooperation with this department made a survey of 314 farms in 11 counties to determine the cost of producing crops. A rural, social, and economic survey of Monongalia County, including the study of farm management on 189 farms in the county, was also begun. The results of an investigation of agricultural production in West Virginia indicated a rapidly increasing investment in agriculture and a diminution in the size of farms and of acreage and production in the case of some crops. Orchard planting was found to be on the increase, and a surplus of beef and mutton was noted.

In the field of horticulture variety tests were made with strawberries, bush fruits, and potatoes, as well as with fertilizers for apples and peaches in commercial orchards. Nitrogen appeared to be the limiting factor in peach production. It was found that seed potatoes grown in the higher altitudes of West Virginia were as good as those from northern States. An attempt is being made to improve the quality of seed potatoes and secure the general cultivation of better varieties of potatoes for commercial purposes. An orchard survey was made of Berkeley and Jefferson Counties and a market-garden survey of Ohio and Kanawha River Valleys. In fertilizer experiments with tomatoes in Morgan County it appeared that the element most efficient in those soils, in so far as the needs of the tomato crop is concerned, is phosphorus. Tests to determine the relative value of different forms of phosphatic fertilizers yielded uncertain results. About 400 pounds of high-grade commercial fertilizers per acre was found to be the limit of the economic use of fertilizers for tomatoes. That amount gave better average net returns than were obtained from 600 pounds per acre.

A study of the effect of green feed for poultry in winter, particularly the effect of sprouted oats, was continued. A determined effort was made to improve the quality of poultry raised in the State. For the furtherance of this purpose 850 White Leghorn cockerels and 20,000 eggs were distributed among farmers.

The following publications were received from this station during the year: Bulletins 140, Potato Culture in West Virginia; 141, The Rejuvenation of Old Orchards; 142, Fertilizer Experiments with Tomatoes; 143, A Market Garden and Truck Survey of the Ohio and Kanawha River Valleys; 144, Agricultural Production in West Virginia; 145, Some Factors Affecting the Weight, Composition, and

Hatchability of Hen Eggs; Circulars 4, A List of Bulletins Available for General Distribution; 6, Lime; 7, Orchard Spraying; Inspection Bulletins 1 and 2, Commercial Fertilizers—Inspection 1912 and 1913; and the Annual Report for 1912.

The income of the station during the past fiscal year was as follows:

|   |               |
|---|---------------|
| United States appropriation, Hatch Act----- | \$15,000.00   |
| United States appropriation, Adams Act----- | 15,000.00     |
| State appropriation-----                    | 19,000.00     |
| Fees-----                                   | 14,403.76     |
| Farm products-----                          | 7,590.16      |
| Miscellaneous-----                          | 14.95         |
| Balance from previous year-----             | 2,293.02      |
| <br>Total-----                              | <br>73,301.89 |

Progress has been made at the West Virginia station in more clearly delimiting the college and station work. This station still needs more land and equipment to be used exclusively for purposes of investigation.

#### WISCONSIN.

**Agricultural Experiment Station of the University of Wisconsin, Madison.**

H. L. RUSSELL, Ph. D., *Director.*

The development and expansion of the work of the Wisconsin station was noted in its largely increased income and facilities for experiment. The new building for agricultural chemistry was sufficiently far advanced for occupation. A new swine barn was erected, adding more satisfactory facilities for taking care of swine. Adequate quarters for the manufacture of hog-cholera serum were also secured. Many improvements were made at the branch stations whereby better opportunities are offered for verifying on a large scale the laboratory and plat experiments of the central station. Dr. S. M. Babcock, after 25 years of active service, retired, becoming professor emeritus. Dr. F. W. Woll resigned to take charge of research work in nutrition at the California station. Conrad Hoffman was succeeded as assistant agricultural bacteriologist by Dr. E. B. Fred, of the Virginia station. W. H. Strowd was appointed chemist in charge of feed and fertilizer control.

*Adams fund projects.*—Further advance was made in the investigation of the mineral nutrition of animals. It is shown that the addition of calcium carbonate or phosphate to grain rations increased the retention of both calcium and phosphorus in growing pigs, resulting in the formation of a heavier skeleton. The relative efficiency of calcium carbonate and calcium phosphate in this regard appeared to depend partly upon the amount of phosphorus present in the grain. Additional calcium supplied to growing pigs increased the size of the shaft of the bone, but did not affect the length or rate of growth.

Large amounts of calcium as compared with low amounts in the ration had no effect on the size or calcium content of the skeleton of the fetus.

The study of the effect of rations containing nutrients from single-plant sources yielded interesting results. It was found impossible to balance a ration prepared from the wheat plant and its various products in such a manner as to produce normal calves, while a ration prepared from the corn plant always produced a vigorous offspring. The deficiency of the wheat ration was shown not to be due to the preponderance in the mineral matter of acids over alkalis or of a disproportion between magnesium and calcium. In connection with this investigation nutrition experiments were conducted with rats, in which it was shown that rats which have grown as far as possible on a diet of casein, dextrin, and inorganic salts make a new growth when small amounts of the ether extract of butter or of egg is added. The rats were unable to make growth, however, when lard, olive oil, lecithin, or cholesterin were added in place of the ether extract of butter or egg. In a comparison of nitrogen from alfalfa hay and corn kernel it was found that alfalfa was as effective in building milk protein as was corn kernel. No indication was obtained of the value of the acid-amid nitrogen.

The results previously published as to the rôle of acids in cheese making were largely put into practice in cheese factories and satisfactory verification was thus obtained of the station findings. The method of making cheese from pasteurized milk enables a fixed-time schedule to be adopted for practically all of the features of the process, so that unskilled labor may be utilized for practically all of the work.

In the continued study of cabbage diseases all soil treatments thus far tested have failed to give satisfactory results. Decided progress was made, however, in breeding resistant strains of cabbage. A variety was found which was quite resistant or almost immune to yellows. From this variety a selected seed strain has been grown, which will soon be generally distributed. A strain of cabbage resistant to rot gave a stand of from 95 to 99 per cent, as compared with a stand of 15 to 20 per cent from imported seed. The study of the blackleg of cabbage was practically completed, and progress was made in the investigation of bacterial rot.

In the investigation of the effect of soil treatment upon the phosphorus content and the availability of phosphorus a new test for soil acidity was devised and seemed to be highly satisfactory for the purpose of the experiment. Marked differences were found to exist among plants in their ability to secure their supply of phosphorus from various compounds of this element in the soil. Apparently plants which have a high lime content, such as legumes, feed vigor-

ously on raw rock phosphate. An examination of the relation of the amount of phosphorus in the plant to the form of phosphate in the soil showed that a number of plants contained relatively high percentages of phosphorus when grown on magnesium phosphate. In this work eight forms of phosphates have been used in quartz-sand cultures with corn, barley, alfalfa, clover, serradella, and millet.

A study of the effects of inbreeding was carried on with poultry and rats. In the poultry work Rhode Island Red fowls are being used and the effect of inbreeding upon color, vigor, vitality, and egg production is being determined. The investigation of the hereditary factors in determining milk and meat production was continued with six first-generation calves, all crosses between Angus and Jerseys, in which attention is given especially to Mendelian segregation of characters. The second generation is expected to be obtained during the coming year for further study.

*Work with Hatch and other funds.*—The experimental and control work carried on by the station under the support of Hatch and other funds was very extensive and was participated in by all departments. The chemical department made a study of the value of nitrogen of alfalfa hay for milk production. It appeared that the nitrogen in alfalfa hay fed in rations of 16 to 18 pounds per cow daily was as effective as an equal amount of nitrogen from corn. The alfalfa hay exercised a marked diuretic property, diminishing in some cases the quantity of milk but not the amount of milk protein. An investigation was also begun on the influence of sulphates on plant growth by means of field and water cultures. The addition of sulphates considerably increased the growth of clover and cruciferous plants. The dairy department carried on several lines of investigation, including a study of the color defects in butter, the causes of excessive richness in buttermilk from pasteurized cream, the economy of pasteurizing milk in bottles, the manufacture of ice cream, methods of washing bottles, and the leakage of water into milk bottles. Mottled butter was found to be due to the size and distribution of the minute drops of water throughout the butter. The addition of salt caused these droplets to run together.

A series of experiments was also carried on to determine the relative economy from the use of soiling crops and silage for dairy cows in summer.

The division of plant pathology, in addition to carrying on Adams fund investigations on cabbage diseases, conducted work on barley diseases in cooperation with this department and accumulated a large fund of information on miscellaneous diseases of cucumbers, potatoes, tobacco, and special diseases which occur in greenhouses. Considerable attention was also given to fire blight, apple scab, crown gall, and other diseases of orchard and small fruits, as well as to pea

blight and diseases which have recently threatened the extensive ginseng industry of the State.

The damping off of seedlings in plant beds was found to be caused either by *Pythium debaryanum* or *Rhizoctonia*, which attack a large variety of plants. Treatment of the soil with formalin was not effective except when used in the proportion of one part formalin to 50 parts water at the rate of 2 quarts per square foot of soil. Sterilization of soil by heat proved to be the most satisfactory method of controlling the trouble. An investigation was also made of black rot and shed burn or stem rot of tobacco. Black rot was shown to be due to *Sterigmatocystis nigra*, which develops on the tobacco leaves in storage, causing them to blacken and decay. The trouble may best be prevented by the proper control of the temperature and moisture of the storage room. Similarly with shed burn or stem rot, the only satisfactory means of control was found in the regulation of the temperature and humidity of the curing shed.

The department of soils devoted particular attention to problems in soil management in relation to various crops. In this work experiments were carried on at all of the substations. Relation of soil acidity to the availability of nitrogen in soils was made the subject of an investigation which has not yet been completed. Soil management studies were begun on sandy soils, heavy clay soils, silt loam soils, and marsh soils. The problems involved in the drainage of certain parts of the State also received considerable attention and much progress was made in a soil survey of the State.

The range of work of the agronomy department was greatly extended. Much attention was given to pedigree grain breeding which is carried on cooperatively with 47 county experimental associations. At the branch stations in the northern part of the State the breeding of wheat and field peas has been begun with promising preliminary results. On the sand plains an attempt is being made to develop suitable crop rotations. The agronomic experiments at the station farm were largely concerned with wheat, peas, sugar beets, and clover, and involved breeding, hybridization, and cultural studies. The culture of hemp in Wisconsin was greatly hindered by the growth of noxious weeds. Practical methods were devised for controlling weeds in hemp. Experiments with alfalfa included a study of winterkilling in relation to the time of seeding and the hardiness of more than 125 strains of alfalfa. The practical problems involved in making a success of wheat and soy beans in the State were carefully considered.

The division of agricultural bacteriology cooperated with the dairy department in the study of cheese, and with the soil department in a study of the biological changes in nitrogen as affected by acidity of the soil. The effect of green manures was found to be somewhat injurious on the germination of cotton, flax, soy beans, hemp, mus-



FIG. 1.—AGRICULTURAL HALL, "JAMES WILSON HALL," COST \$150,000, WASHINGTON STATION.

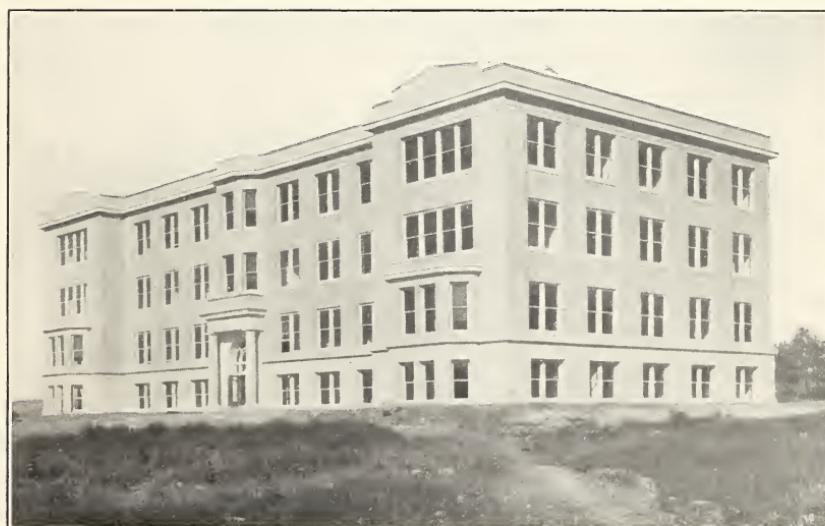


FIG. 2.—AGRICULTURAL HALL, COST \$100,000, CONTAINS OFFICE OF THE STATION, WYOMING COLLEGE AND STATION.



tard, and lupines, but not on that of corn, oats, wheat, buckwheat, or sunflower. When, however, the green vegetable matter was allowed to decompose before the seeds were planted the germination of seed was not affected. In a study of the relation of carbon bisulphid to soil organisms and plant growth it was found that the carbon bisulphid does not wholly evaporate from the soil, and that some of it may be changed to sulphates, thus bringing the problem into relation with the sulphur question. A beginning has also been made on the study of cellulose fermentation and on the influence of protozoa upon the soil bacteria.

The horticultural work during the year included a study of root hardiness of fruit trees in connection with injury from freezing, an investigation of cranberry problems, laboratory work on the effect of freezing on various plants, crossing experiments with fruits and vegetables, particularly cabbage, fertilization of potatoes, cherries, and rhubarb, and the development of scion roots to determine whether these are more hardy than stock roots. In the cranberry work 176 varietal strains were kept under observation in the nursery. The work of the entomological department consisted chiefly in devising a practical method for the control of onion maggots, a study of the tobacco splitworm and other tobacco insects, and in making a general survey of the insect pests of the State.

The department of agricultural economics conducted an investigation of potato marketing, including the various factors of cost from the warehouse to the consumer. A similar investigation had already been made of the marketing of cheese and the same method may be applied to other farm products. A beginning has been made on a historical economic study of agriculture in the United States from 1840 to 1860. The investigation of rural social centers, agricultural cooperation, farm cost accounting, and rural credits was continued actively. The experimental work of the animal-husbandry department is largely of research nature and organized into Adams' fund projects. During the year the results of observations of the department on methods for feeding sheep and lambs for exhibition purposes were published.

The following publications were received from this station during the year: Bulletins 230, Soil Acidity and Liming; 232, Fitting Yearling Wethers and Lambs for Exhibition; 233, Wheat Growing in Wisconsin; 234, Rural Social Centers in Wisconsin; 235, Soiling Crops versus Silage for Dairy Cows in Summer; 236, Soy Beans—An Important Wisconsin Crop; 237, The Control of Diseases and Insects of Tobacco; 238, Agricultural Cooperation; Research Bulletins 29, Nature of the Changes in the Solubility and Availability of Phosphorus in Fermenting Mixtures; 30, Calcium and Phosphorus Supply of Farm Feeds and Their Relation to the Animal's Requirements;

31, The Control of Damping-off Disease in Plant Beds; Circulars of Information 45, Distribution of Public Service Stallions Enrolled in the Counties of Wisconsin During 1913; 46, Commercial Feeding Stuffs and Fertilizers Licensed for Sale in Wisconsin, 1914; and 48, How to Rid Our Farms of Weeds; and the Annual Report for 1912.

The income of the station during the past fiscal year was as follows:

|   |          |
|---|----------|
| United States appropriation, Hatch Act----- | \$15,000 |
| United States appropriation, Adams Act----- | 15,000   |
| State appropriation-----                    | 50,000   |
| Fees -----                                  | 12,016   |
| Total -----                                 | 92,016   |

The generous State support which the Wisconsin station has received has enabled it to carry the results of its investigations to the farming population of the State to an unusually wide extent. The influence of the investigational work of the station has been diffused effectively through its substations and the numerous county experimental associations. The research work of the main station continues upon a high plane.

#### WYOMING.

##### Wyoming Agricultural Experiment Station, Laramie.

H. G. KNIGHT, A. M., Director.

The year was one of satisfactory progress for the Wyoming station in all lines of endeavor. The income of the station was slightly reduced by change in the mill tax, but this reduction of income did not appreciably interfere with the scientific and experimental operations, although some strict economy had to be practiced in the administration of funds. The new agricultural hall (Pl. VIII, fig. 2) was completed, at a cost of about \$100,000. The entire lower floor of this building is devoted to the experiment station. Equipment was ordered for laboratories and other station work. A silo was built for experiments in dairying. Dr. L. D. Swingle, bacteriologist, resigned, and his place was filled by Dr. J. W. Scott. O. A. Beath was appointed assistant chemist in place of E. V. Lynn, resigned. Other changes in the station staff were of minor importance.

*Adams fund projects.*—The investigation of poisonous range plants was continued actively and with satisfactory results. The active poisonous principle in woody aster was isolated and was believed to be a glucosid. The active alkaloid of *Zygadenus intermedius* was recovered in a pure crystalline form. The crystals melt at 200° to 201°, and an analysis of these crystals indicates a formula C<sub>39</sub>H<sub>63</sub>NO<sub>10</sub>. By gravimetric method it was determined that the

leaves of the death camas yield 0.3 to 0.4 per cent of a crude alkaloid mixture. The alkaloid is called zygadenin. Its physiological action is similar to veratrin. Considerable progress was made in a comparison of the alkaloids present in the larkspurs found upon the range, particularly *Delphinium glaucum*, *D. geyeri*, and *D. glaucescens*. Large quantities of dried leaves, stems, and flowers of lupines were extracted with alcohol and analytical work begun to determine the chemical nature of the active principle.

In the study on the effect of alkali upon cement, briquettes of the material were kept in solutions containing chlorids, sulphates, and carbonates. The sulphates of sodium and magnesium were most active in causing disintegration, while carbonates came next and chlorids last. Cements which contained a large proportion of sand were less resistant than the stronger mixtures. The action of alkali upon the cement appeared to be one of solution and extraction of lime rather than a change in molecular structure. Calcium sulphate in crystalline form was extracted from the cement, and formed as a deposit on the surface of the blocks and not upon the inside of the cement blocks.

From the continued study of wool it was found that the wool from Wyoming sheep was heavier immediately after removal of the fleece, but that the fleece from Ohio sheep was heavier after washing. Tests of strength of wool fibers indicated no difference between the Wyoming and Ohio wools. The effect of feed upon the weight of fleece and strength of wool appeared to be not of much importance. Both the grease weight and clean weight of the wool were apparently in favor of the narrow ration, but the strength of the fiber was not affected by any modification of the ration.

As a result of a study of the means of transmission of swamp fever in horses, it appeared that horseflies can not be considered an important agent in carrying this disease. The possibility remains that the disease is transmitted by the stable fly or mosquitoes. Experiments were instituted to determine this point. An effort was continued to determine the intermediate hosts for the sheep tapeworm *Thysanosoma actinioides*. The morphology of this tapeworm was carefully worked out and the anatomical features were described in detail.

The life cycle of the sheep tick was rather definitely determined. It was found that the egg is laid as a larva, which pupates 12 hours later. The time required for female ticks to reach maturity varied from 14 to 30 days. The whole life of the tick is spent on the sheep. It was determined that they will not live more than a few days when removed from the sheep. Experiments were also begun to determine the conditions under which infestation with *Tænia expansa* occurs. Negative results were obtained from the feeding of

muscle tissue to determine whether *Sarcocystis tenella* could be transmitted in this way. The parasite is found in the muscles of sheep quite frequently in Wyoming, and further attempts will be made to determine the details of its life history.

*Work with Hatch and other funds.*—With the aid of Hatch and other funds a considerable variety of experiments were carried forward. Silage from all available materials was tested. Oat silage appeared to give excellent results. Oat and pea silage were used in feeding experiments with lambs, ewes, beef cattle, and dairy cows. Profitable returns were obtained from feeding alfalfa silage to lambs. The economy and practicability of silos were demonstrated even where corn can not be successfully raised. Other experimental work in animal industry included digestion experiments with sheep, feeding experiments with pigs on pasture, rations for fattening lambs, maintenance rations for beef cattle, and winter rations for breeding ewes.

Experiments were conducted with alfalfa to determine the various cultural and water requirements of this plant under different conditions. Grimm alfalfa gave the best results. Variety and cultural tests were also made with barley, wheat, oats, potatoes, peas, and root crops. Some experiments were begun to determine the effect of legumes on the following crops. Sweet clover was used in some of these experiments to determine its value and adaptability under Wyoming conditions.

The miscellaneous experiments of the station include tests of fertilizers and various systems of rotation. The results of 20 years' observations on the meteorological conditions of Wyoming were tabulated.

The following publications were received from this station during the year: Bulletins 99, The Life History of the Sheep Tick (*Melophagus ovinus*) ; 100, Meteorology for Twenty Years; 101, Zygadenin—The Crystalline Alakloid of *Zygadenus intermedium*; 102, The Morphology of the Sheep Tapeworm (*Thysanosoma actinioides*) ; and the Annual Report for 1913:

The income of the station during the past fiscal year was as follows:

|  |             |
|--|-------------|
| United States appropriation, Adams Act | \$15,000.00 |
| United States appropriation, Hatch Act | 15,000.00   |
| Farm products                          | 1,282.01    |
| Balance from previous year             | 1,095.38    |
| Total                                  | 32,377.39   |

The research work of the station is organized on a sound basis and is yielding clear and definite results. The satisfactory progress of the station is in part due to the excellent esprit de corps of the staff.

**STATISTICS OF THE AGRICULTURAL EXPERIMENT STATIONS.**

The total income of the experiment stations during 1914 was \$5,164,687.96. Of this amount \$712,649.08 was derived under the Hatch Act, \$713,517.91 under the Adams Act, \$2,574,605.27 from State appropriations, \$19,784.87 from individuals and communities, \$234,794.67 from fees, \$307,615.40 from farm products, and \$491,756.76 from miscellaneous sources. In addition, the Office of Experiment Stations had an appropriation of \$461,260, including \$35,000 for the Alaska station, \$30,000 each for the experiment stations in Hawaii and Porto Rico, and \$15,000 for the Guam Experiment Station.

The value of additions to the equipment of stations was estimated as follows:

|                 |              |
|-----------------|--------------|
| Buildings       | \$609,199.92 |
| Libraries       | 28,621.96    |
| Apparatus       | 83,447.24    |
| Farm implements | 76,169.79    |
| Live stock      | 131,915.52   |
| Miscellaneous   | 83,016.28    |
| Total           | 1,012,370.71 |

The stations employed 1,852 persons in the work of administration and inquiry. Of this number 905 were also members of the teaching staff of the colleges and 590 assisted in farmers' institutes. During the year the stations published 1,330 annual reports, bulletins, and circulars, aggregating 25,265 pages, and these were distributed to 1,049,339 addresses on the regular mailing list.

The detailed statistics of the stations by States are shown in the tables following.

## General statistics, 1914.

| Station.             | Location.                  | Director.        | Date of original organization. | Date of organization under Hatch Act. | Number of persons on staff. | Number of teachers on staff. | Number of persons on staff who assist in farmers' institutes. | Number of publications during fiscal year 1913-14. | Number of names on mailing list. |
|----------------------|----------------------------|------------------|--------------------------------|---------------------------------------|-----------------------------|------------------------------|---|--|----------------------------------|
|                      |                            |                  |                                |                                       |                             |                              |   | Number of pages.                                   |                                  |
| Alabama (College)    | Auburn                     | J. F. Duggar     | Feb. 1, 1883                   | Feb. 24, 1888                         | 31                          | 14                           | 18  | 13   | 168                              |
| Alabama (Canebrake)  | Uniontown                  | L. H. Moore      | Jan. 1, 1886                   | Apr. 1, 1888                          | 18                          | 19                           | 19  | 1  | 96                               |
| Alabama              | Tusgee Institute           | G. W. Carver     | Feb. 15, 1897                  |                                       | 8                           | 8                            | 5   | 46   | 428                              |
| Alaska               | Sitka                      | C. C. Georgeson  |                                |                                       | 16                          | 8                            | 5   | 18   | 1,900                            |
| Arizona              | Tucson                     | R. H. Forbes     |                                |                                       | 18                          | 14                           | 5   | 121  | 22,500                           |
| Arkansas             | Forneyville                | Martin Nelson    |                                |                                       | 100                         | 71                           | 78  | 27   | 38,000                           |
| California           | Berkeley                   | T. F. Hunt       | 1875                           | Mar. 27, 1888                         | 25                          | 4                            | 11  | 8  | 22,000                           |
| Colorado             | Fort Collins               | C. P. Gillette   |                                | Feb. 29, 1888                         | 19                          | 19                           | 6   | 8  | 11,569                           |
| Connecticut (State)  | New Haven                  | E. H. Jenkins    | Oct. 1, 1875                   | May 18, 1887                          | 13                          | 7                            | 9   | 138  | 9,600                            |
| Connecticut (Storrs) | Storrs                     | do               |                                | May 18, 1887                          | 13                          | 7                            | 9   | 425  | 10,000                           |
| Delaware             | Newark                     | Harry Hayward    |                                | Feb. 21, 1888                         | 14                          | 8                            | 6   | 5  | 94                               |
| Florida              | Gainesville                | P. H. Rols       |                                | Feb. 18, 1888                         | 16                          | 6                            | 6   | 20   | 8,000                            |
| Georgia              | John H. DeLoach            |                  |                                | July 1, 1889                          | 9                           | 9                            | 6   | 20   | 21,000                           |
| Ghent                | Graham                     | John B. Thompson |                                |                                       | 4                           | 4                            | 10  | 10   | 9,000                            |
| Hawaii               | Honolulu                   | E. V. Wilcox     |                                |                                       | 14                          | 4                            | 2   | 53   | 33                               |
| Idaho                | Moscow                     | W. L. Cartile    |                                | Feb. 26, 1892                         | 25                          | 13                           | 5   | 31   | 7,000                            |
| Illinois             | Urbana                     | Eugene Davenport |                                | Mar. 21, 1888                         | 94                          | 65                           | 40  | 20   | 27,400                           |
| Indiana              | Lafayette                  | Arthur Goss      |                                | Jan. 17, 1888                         | 50                          | 16                           | 27  | 23   | 884                              |
| Iowa                 | Ames                       | C. F. Curtiss    |                                | Feb. 17, 1888                         | 44                          | 14                           | 34  | 670  | 45,573                           |
| Kansas               | Manhattan                  | W. M. Jordine    |                                | Feb. 8, 1888                          | 69                          | 39                           | 39  | 25   | 27,000                           |
| Kentucky             | Lexington                  | J. H. Kastle     | Sept. 1, 1885                  | Apr. 1, 1888                          | 50                          | 13                           | 3   | 52   | 876                              |
| Louisiana (Sugar)    | New Orleans                | W. R. Douison    | do                             | Sept. 1, 1885                         | 185                         | 186                          | 13  | 3  | 18,000                           |
| Louisiana (State)    | Baton Rouge                | do               |                                | Apr. 1, 1886                          | 186                         | 186                          | 13  | 3  | 353                              |
| Louisiana (North)    | Calhoun                    | do               |                                | May 1, 1887                           | 187                         | 187                          | 16  | 27   | 7,000                            |
| Maine                | Orono                      | C. D. Woods      |                                | Mar. 1, 1885                          | 27                          | 2                            | 8   | 8  | 283                              |
| Maryland             | College Park               | E. J. Patterson  |                                | Oct. 1, 1887                          | 22                          | 5                            | 4   | 45   | 9,000                            |
| Massachusetts        | Amherst                    | W. P. Brooks     |                                | Apr. 1, 1888                          | 24                          | 5                            | 4   | 8  | 15,000                           |
| Michigan             | East Lansing               | R. S. Shaw       |                                | Mar. 2, 1888                          | 35                          | 12                           | 8   | 262  | 25,000                           |
| Minnesota            | St. Anthony Park, St. Paul | A. F. Woods      |                                | Feb. 26, 1888                         | 35                          | 28                           | 9   | 33   | 20,028                           |
| Mississippi          | Missouri (College)         | E. B. Lloyd      |                                | Mar. 7, 1885                          | 89                          | 30                           | 9   | 25   | 345                              |
| Missouri (Truit)     | Columbia                   | F. B. Mumford    |                                | Jan. 27, 1888                         | 24                          | 9                            | 11  | 19   | 65,000                           |
| Montana              | Bozeman                    | do               |                                | Jan. 1, 1888                          | 57                          | 50                           | 15  | 42   | 312                              |
| Nebraska             | Lincoln                    | F. B. Linfield   |                                | Feb. 1, 1900                          | 10                          | 8                            | 8   | 39   | 6,062                            |
| Nevada               | Reno                       | E. A. Burnett    | July 1, 1893                   | Dec. 16, 1884                         | 18                          | 6                            | 9   | 212  | 17,740                           |
| New Hampshire        | Durham                     | S. B. Doten      | do                             | June 13, 1887                         | 37                          | 4                            | 6   | 300  | 6,300                            |
| New Jersey (State)   | New Brunswick              | J. C. Kendall    | 1886                           | Dec. 4, 1887                          | 18                          | 10                           | 13  | 5  | 16,000                           |
|                      | New Jersey (State)         | J. G. Lipman     | Mar. 10, 1880                  | Aug. 31, 1887                         | 31                          | 15                           | 38  | 1,075  | 9,922                            |

In 1882 the State organized a station here and maintained it until June 18, 1895, when it was combined with the Hatch station at the same place.

Acting Director.

## Revenue and additions to

| Station                      | Federal.    |             | State.        | Individuals and communities. | Fees.       | Farm products. | Miscellaneous. |
|------------------------------|-------------|-------------|---------------|------------------------------|-------------|----------------|----------------|
|                              | Hatch fund. | Adams fund. |               |                              |             |                |                |
| 1 Alabama (College).         | \$15,000.00 | \$15,000.00 | 1 \$30,148.47 | .....                        | .....       | \$995.48       | \$3,525.71     |
| 2 Alabama (Cane-brake).      | .....       | .....       | .....         | .....                        | .....       | .....          | .....          |
| 3 Alabama (Tuskegee).        | .....       | .....       | .....         | .....                        | .....       | .....          | .....          |
| 4 Alaska.                    | .....       | .....       | .....         | .....                        | 1 12,740.79 | .....          | .....          |
| 5 Arizona.                   | 15,000.00   | 15,000.00   | 62,943.64     | .....                        | 1 5,143.64  | 2,779.83       | .....          |
| 6 Arkansas.                  | 15,000.00   | 15,000.00   | 49,000.00     | 1 \$1,791.88                 | 2,529.07    | 6,513.48       | .....          |
| 7 California.                | 15,000.00   | 15,000.00   | 150,000.00    | .....                        | 88,000.00   | 5,000.00       | 12,409.96      |
| 8 Colorado.                  | 15,000.00   | 15,000.00   | 10,301.87     | .....                        | .....       | 288.60         | 7,408.26       |
| 9 Connecticut (State)        | 7,500.00    | 7,500.00    | 26,375.00     | 10,200.49                    | 9,635.72    | 7.98           | 46.98          |
| 10 Connecticut (Storrs).     | 7,500.00    | 7,500.00    | 1 4,852.56    | .....                        | .....       | .....          | 1 3,249.34     |
| 11 Delaware.                 | 15,000.00   | 15,000.00   | .....         | .....                        | 11,101.00   | .....          | .....          |
| 12 Florida.                  | 15,000.00   | 15,000.00   | .....         | .....                        | 1,565.69    | 1 24.09        | .....          |
| 13 Georgia.                  | 15,000.00   | 15,000.00   | 706.45        | .....                        | 4,209.16    | 3 4,586.77     | .....          |
| 14 Guam.                     | .....       | .....       | .....         | .....                        | 1 361.05    | .....          | .....          |
| 15 Hawaii.                   | .....       | .....       | 17,336.92     | .....                        | 704.54      | .....          | .....          |
| 16 Idaho.                    | 15,000.00   | 15,000.00   | .....         | .....                        | 14,134.42   | .....          | .....          |
| 17 Illinois.                 | 15,000.00   | 15,000.00   | 1 227,761.30  | .....                        | 1 40,859.26 | .....          | .....          |
| 18 Indiana.                  | 15,000.00   | 15,000.00   | 91,000.00     | .....                        | .....       | 194,363.20     | .....          |
| 19 Iowa.                     | 15,000.00   | 15,000.00   | 99,200.00     | .....                        | 14,985.97   | 1 17,900.29    | .....          |
| 20 Kansas.                   | 15,000.00   | 15,000.00   | 81,453.90     | .....                        | 16,449.12   | .....          | .....          |
| 21 Kentucky.                 | 15,000.00   | 15,000.00   | 1 105,608.12  | 1 67,550.69                  | 14,133.96   | 1 68,461.16    | .....          |
| 22 Louisiana.                | 15,000.00   | 15,000.00   | 22,000.00     | 6,000.00                     | .....       | 4,149.27       | .....          |
| 23 Maine.                    | 15,000.00   | 15,000.00   | 1 6,636.75    | .....                        | .....       | 1 8,535.11     | .....          |
| 24 Maryland.                 | 15,000.00   | 15,000.00   | 10,073.51     | .....                        | 1 9,115.35  | .....          | .....          |
| 25 Massachusetts.            | 15,000.00   | 15,000.00   | 1 35,074.55   | 11,244.00                    | 9,061.91    | 9,631.40       | .....          |
| 26 Michigan.                 | 15,000.00   | 15,000.00   | 18,000.00     | 6,280.00                     | .....       | 1 6,112.90     | .....          |
| 27 Minnesota.                | 15,000.00   | 15,000.00   | 366,068.54    | .....                        | .....       | .....          | .....          |
| 28 Mississippi.              | 15,000.00   | 15,000.00   | 6 33,525.00   | .....                        | 6,812.79    | 1 1,797.02     | .....          |
| 29 Missouri (College).       | 15,000.00   | 15,000.00   | 24,151.22     | 1 26,916.55                  | 16,845.68   | 1 17,287.92    | .....          |
| 30 Missouri (Fruit).         | .....       | .....       | .....         | .....                        | .....       | .....          | .....          |
| 31 Montana.                  | 15,000.00   | 15,000.00   | 31,342.03     | 1,045.36                     | 6,111.05    | .....          | .....          |
| 32 Nebraska.                 | 15,000.00   | 15,000.00   | 1 67,750.00   | .....                        | .....       | 1 51,365.61    | .....          |
| 33 Nevada.                   | 15,000.00   | 15,000.00   | 4,550.00      | .....                        | 1 468.61    | .....          | .....          |
| 34 New Hampshire.            | 15,000.00   | 15,000.00   | .....         | .....                        | 1,445.53    | 1 9,363.05     | .....          |
| 35 New Jersey (State).       | .....       | .....       | 72,043.57     | 37,448.68                    | 14,814.90   | .....          | 285.00         |
| 36 New Jersey (College).     | 15,000.00   | 15,000.00   | .....         | .....                        | .....       | .....          | .....          |
| 37 New Mexico.               | 15,000.00   | 15,000.00   | 200.00        | .....                        | 1,351.51    | 3 2,490.81     | .....          |
| 38 New York (State).         | 1,500.00    | 1,500.00    | 1 142,962.83  | .....                        | .....       | .....          | .....          |
| 39 New York (Cornell).       | 13,500.00   | 13,500.00   | .....         | .....                        | .....       | .....          | .....          |
| 40 North Carolina.           | 15,000.00   | 15,000.00   | .....         | .....                        | 13,244.00   | 4,950.00       | .....          |
| 41 North Dakota.             | 15,000.00   | 15,000.00   | 1 16,468.81   | .....                        | .....       | 1 12,209.17    | .....          |
| 42 Ohio.                     | 15,000.00   | 15,000.00   | 1 419,488.54  | .....                        | 1 21,016.01 | 10,914.27      | .....          |
| 43 Oklahoma.                 | 7,649.08    | 8,517.91    | 5,000.00      | .....                        | 3,241.15    | 2,137.06       | .....          |
| 44 Oregon.                   | 15,000.00   | 15,000.00   | 1 80,943.99   | 5,113.76                     | 1 7,653.30  | 11,005.16      | .....          |
| 45 Pennsylvania.             | 15,000.00   | 15,000.00   | 6,000.00      | .....                        | 14,067.00   | 1 24,818.38    | 117.71         |
| 46 Pennsylvania (Nutrition). | .....       | .....       | .....         | .....                        | .....       | .....          | .....          |
| 47 Porto Rico.               | .....       | .....       | .....         | .....                        | 1 2,699.85  | 1 6,060.81     | .....          |
| 48 Rhode Island.             | 15,000.00   | 15,000.00   | .....         | .....                        | 1 2,370.72  | .....          | .....          |
| 49 South Carolina.           | 15,000.00   | 15,000.00   | .....         | .....                        | 1 9,593.32  | 1 4,144.14     | .....          |
| 50 South Dakota.             | 15,000.00   | 15,000.00   | 17,000.00     | .....                        | 9,622.11    | .....          | .....          |
| 51 Tennessee.                | 15,000.00   | 15,000.00   | .....         | .....                        | 1 976.54    | 2,360.94       | 3 712.54       |
| 52 Texas.                    | 15,000.00   | 15,000.00   | 8 37,500.00   | 11,397.38                    | .....       | .....          | .....          |
| 53 Utah.                     | 15,000.00   | 15,000.00   | 18,058.54     | .....                        | .....       | .....          | .....          |
| 54 Vermont.                  | 15,000.00   | 15,000.00   | 1,000.00      | .....                        | 4,318.73    | .....          | .....          |
| 55 Virginia.                 | 15,000.00   | 15,000.00   | 21,250.00     | .....                        | 3,226.52    | 1 3,320.88     | .....          |
| 56 Virginia (Truck).         | .....       | .....       | .....         | .....                        | .....       | .....          | .....          |
| 57 Washington.               | 15,000.00   | 15,000.00   | 41,529.16     | .....                        | 1 464.42    | 1 3,132.45     | 494.51         |
| 58 West Virginia.            | 15,000.00   | 15,000.00   | 19,000.00     | .....                        | 14,403.76   | 7,590.16       | 1 2,307.97     |
| 59 Wisconsin.                | 15,000.00   | 15,000.00   | 50,000.00     | .....                        | 12,016.00   | .....          | .....          |
| 60 Wyoming.                  | 15,000.00   | 15,000.00   | .....         | .....                        | 1,282.01    | 2 1,095.38     | .....          |
| Total.                       | 712,649.08  | 713,517.91  | 2,574,605.27  | 19,748.87                    | 234,794.67  | 307,615.40     | 491,753.76     |

<sup>1</sup> Including balance from previous year.<sup>2</sup> Including \$35,000 Federal appropriation.<sup>3</sup> Balance from previous year.<sup>4</sup> Including \$15,000 Federal appropriation.<sup>5</sup> Including \$30,000 Federal appropriation.

## STATISTICS OF THE EXPERIMENT STATIONS.

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equipment, 1913-14.

| Total.         | Additions to equipment. |           |            |                       |                |                     |              | Total. |
|----------------|-------------------------|-----------|------------|-----------------------|----------------|---------------------|--------------|--------|
|                | Buildings.              | Library.  | Apparatus. | Farm im-<br>plements. | Live<br>stock. | Miscel-<br>laneous. |              |        |
| \$64,669.66    | \$730.00                | \$593.00  | \$575.00   | \$954.00              | \$120.00       | \$89.00             | \$3,062.00   | 1<br>2 |
|                |                         |           |            | 66.75                 |                |                     | 66.75        | 3      |
| 2,47,740.79    | 409.23                  |           |            | 775.67                | 409.23         |                     | 1,594.13     | 4      |
| 100,867.11     | 37,087.52               | 173.69    | 1,763.75   | 2,068.00              | 129.50         |                     | 41,222.46    | 5      |
| 89,834.43      | 200.00                  | 100.00    | 1,700.00   | 1,050.00              | 1,500.00       | 250.00              | 4,800.00     | 6      |
| 205,499.96     | 10,532.76               | 142.72    | 574.04     |                       | 14.70          | 709.85              | 11,974.07    | 7      |
| 47,998.73      | 238.74                  |           |            | 521.27                | 17.00          |                     | 777.01       | 8      |
| 61,766.17      | 1,654.57                | 723.07    | 89.17      | 191.73                |                |                     | 2,658.54     | 9      |
| 23,101.90      | 424.08                  | 144.93    | 199.19     | 302.99                | 46.50          |                     | 1,117.69     | 10     |
| 41,101.00      | 1,058.87                | 122.37    | 386.91     | 1,634.83              | 2,274.55       | 270.00              | 5,747.53     | 11     |
| 31,589.78      | 700.00                  | 300.00    | 400.00     | 250.00                | 275.00         | 275.00              | 2,200.00     | 12     |
| 4,39,502.33    | 6,996.00                | 359.30    | 1,713.21   | 987.05                |                | 1,200.00            | 11,254.56    | 13     |
| 4,15,361.05    | 103.79                  | 125.18    | 6.00       | 191.66                | 310.00         | 184.25              | 920.88       | 14     |
| 5,48,041.46    | 2,874.79                | 493.36    | 42.48      | 1,042.34              | 476.00         |                     | 4,928.97     | 15     |
| 44,134.42      | 6,830.00                | 87.46     | 372.55     | 1,710.27              | 4,138.25       | 406.55              | 13,545.08    | 16     |
| 298,620.56     | 13,896.97               | 117.16    | 6,742.64   | 3,676.63              | 6,451.38       | 2,678.51            | 33,563.29    | 17     |
| 315,363.20     | 28,968.65               | 655.66    | 2,197.98   | 1,805.27              | 40,419.79      | 3,302.39            | 77,349.74    | 18     |
| 162,086.20     | 22,152.85               |           | 1,282.90   | 1,369.70              | 2,092.63       |                     | 26,898.08    | 19     |
| 127,903.02     | 8,367.02                | 438.22    | 2,528.81   | 2,756.05              | 6,983.11       | 4,059.58            | 25,132.79    | 20     |
| 285,573.93     | 11,828.00               | 1,781.70  | 8,727.94   | 897.58                | 1,500.00       |                     | 24,740.53    | 21     |
| 62,149.27      |                         | 133.20    | 386.87     | 1,504.82              | 1,277.00       |                     | 3,301.89     | 22     |
| 45,171.86      | 27,500.00               | 900.00    | 1,100.00   | 1,200.00              | 1,800.00       |                     | 32,500.00    | 23     |
| 49,188.86      | 1,507.00                | 498.26    | 1,830.09   | 1,248.13              | 8.53           | 834.31              | 5,926.32     | 24     |
| 95,011.86      | 1,175.67                | 560.76    | 1,085.32   | 539.39                | 87.50          |                     | 3,468.64     | 25     |
| 60,392.90      | 2,019.71                | 806.82    | 1,586.86   | 887.36                | 5,163.39       |                     | 10,464.14    | 26     |
| 396,068.54     | 56,600.00               | 4,307.04  | 14,190.64  | 4,304.97              | 11,467.25      | 17,091.23           | 107,961.13   | 27     |
| 72,134.81      | 1,381.00                | 149.80    | 437.83     | 1,301.00              | 10,835.51      | 1,444.98            | 15,550.12    | 28     |
| 115,201.37     | 104,000.00              | 2,000.00  | 650.00     | 258.00                | 2,000.00       | 1,000.00            | 109,908.00   | 29     |
|                |                         |           |            |                       |                |                     |              | 30     |
| 68,498.44      | 500.00                  | 125.00    | 1,250.00   | 1,600.00              | 600.00         |                     | 4,075.00     | 31     |
| 149,115.61     | 10,038.00               | 58.39     | 1,769.89   | 452.00                | 415.00         | 1,000.00            | 13,733.28    | 32     |
| 35,018.61      | 658.10                  | 457.34    | 2,702.06   | 2,673.91              |                | 1,449.60            | 7,941.01     | 33     |
| 40,808.58      | 369.70                  | 476.75    | 1,499.58   | 866.25                | 969.50         | 408.17              | 4,589.95     | 34     |
| 121,307.15     |                         | 72.69     | 539.03     | 1,504.95              | 910.00         |                     | 3,056.67     | 35     |
| 30,285.00      | 405.51                  | 485.43    | 355.18     | 302.00                | 260.00         | 222.60              | 2,030.72     | 36     |
| 34,042.32      | 575.12                  | 11.21     | 1,058.91   | 620.13                | 710.00         | 852.93              | 3,828.30     | 37     |
| 145,962.83     |                         | 1,297.68  | 2,579.20   | 599.70                |                | 564.55              | 5,011.13     | 38     |
| 27,000.00      | 650.49                  | 130.34    | 789.55     | 782.64                |                | 24,6'6.98           | 27,000.00    | 39     |
| 48,191.00      | 7,000.00                | 358.15    | 276.17     | 160.50                | 326.00         | 112.00              | 8,282.82     | 40     |
| 58,677.98      | 54,523.81               | 2,304.58  | 3,119.67   | 8,393.82              | 2,761.63       | 5,741.25            | 76,847.76    | 41     |
| 481,418.82     | 38,855.00               | 1,550.51  | 3,088.28   | 782.42                | 4,804.61       |                     | 49,080.85    | 42     |
| 26,545.20      | 1,300.50                | 89.54     |            | 161.00                | 331.92         |                     | 1,882.96     | 43     |
| 134,716.21     | 9,219.00                | 841.00    | 400.00     | 5,620.00              | 6,562.00       | 5,151.00            | 27,793.00    | 44     |
| 75,003.09      |                         | 169.67    | 916.76     | 500.00                | 1,500.00       |                     | 3,086.43     | 45     |
|                |                         | 200.00    | 600.00     |                       |                |                     | 800.00       | 46     |
| 5,32,699.85    | 483.98                  | 239.89    | 80.85      | 128.50                | 208.45         |                     | 1,141.67     | 47     |
| 36,060.81      |                         | 8'0.00    | 250.00     | 500.00                | 110.00         | 300.00              | 2,020.00     | 48     |
| 32,370.72      | 4,194.14                | 105.27    | 430.54     | 882.93                | 350.00         | 252.74              | 6,215.22     | 49     |
| 60,737.46      | 6,750.00                | 14.50     | 270.00     | 1,980.00              | 1,600.00       | 600.00              | 11,214.50    | 50     |
| 39,(22.11)     | 4,500.00                | 368.03    | 449.04     | 1,3'3.89              | 89             | 802.49              | 7,413.45     | 51     |
| 119,873.92     | 13,527.89               | 249.03    | 334.90     | 4,717.48              | 1,482.50       | 45.00               | 20,356.80    | 52     |
| 51,132.02      | 917.00                  | 63.00     | 235.00     | 1,733.00              | 1,192.00       | 541.00              | 4,686.00     | 53     |
| 33,318.73      | 1,115.63                | 136.99    | 992.38     | 46.96                 | 25.50          |                     | 2,317.46     | 54     |
| 57,797.40      | 3,265.19                | 247.00    | 743.45     | 1,115.94              | 851.50         | 649.56              | 6,872.64     | 55     |
|                |                         |           |            |                       |                |                     |              | 56     |
| 75,620.54      | 4,600.00                | 251.00    | 1,500.00   | 998.00                | 500.00         | 831.00              | 8,680.00     | 57     |
| 73,301.89      | 265.68                  | 623.17    | 2,515.69   | 476.01                | 2,096.35       | 966.39              | 6,943.29     | 58     |
| 92,016.00      | 22,562.98               | 1,016.54  | 3,082.58   | 3,037.80              | 2,918.40       | 1,624.51            | 34,242.81    | 59     |
| 32,377.39      | 73,684.98               | 95.25     | 1,057.35   | 715.50                | 600.31         | 2,458.86            | 78,612.25    | 60     |
| 9,5,164,687.96 | 609,199.92              | 28,621.96 | 83,447.24  | 76,169.79             | 131,915.52     | 83,016.28           | 1,012,370.71 |        |

\* For substations.

† Including amount used for substations.

‡ For 2 years.

§ Including \$110,000 Federal appropriation to Alaska, Guam, Hawaii, and Porto Rico.

*Expenditures from United States appropriation received under the act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1914.*

| Station.                | Amount of appropriation. | Classified expenditures. |            |               |                         |                      |                         |                    |                                     |
|-------------------------|--------------------------|--------------------------|------------|---------------|-------------------------|----------------------|-------------------------|--------------------|-------------------------------------|
|                         |                          | Salaries.                | Labor.     | Publications. | Postage and stationery. | Freight and express. | Heat, light, and water. | Chemical supplies. | Seeds, plants, and sundry supplies. |
| Alabama.....            | \$15,000.00              | \$7,525.83               | \$1,558.91 | \$1,289.78    | \$423.07                | \$272.05             | \$749.16                | \$750.08           | \$220.66                            |
| Arizona.....            | 15,000.00                | 7,137.95                 | 2,294.07   | 319.11        | 1,330.20                | 317.70               | 126.74                  | 4.10               | 504.12                              |
| Arkansas.....           | 15,000.00                | 8,682.14                 | 599.41     | 501.90        | 552.10                  | 205.68               | 440.15                  | 3.46               | 294.84                              |
| California.....         | 15,050.00                | 10,033.14                | 1,570.69   | 2,173.70      | 326.19                  | 184.78               | 3.46                    | 25.97              | 99.80                               |
| Colorado.....           | 15,000.00                | 9,969.26                 | 996.37     | 975.45        | 542.16                  | 28.78                | 215.57                  | .....              | 181.70                              |
| Connecticut (State)     | 7,500.00                 | 6,894.38                 | 416.00     | .....         | .....                   | .....                | .....                   | .....              | .....                               |
| Connecticut (Storrs)    | 7,500.00                 | 7,115.86                 | 148.08     | .....         | 369.34                  | 211.41               | 392.30                  | 14.94              | 11.63                               |
| Delaware.....           | 15,000.00                | 7,734.85                 | 3,018.87   | 653.20        | 436.02                  | 125.58               | 155.20                  | .....              | 767.68                              |
| Florida.....            | 15,000.00                | 7,291.65                 | 3,257.83   | 687.60        | 588.37                  | 274.15               | 331.39                  | 18.00              | 164.38                              |
| Georgia.....            | 15,000.00                | 6,269.54                 | 2,432.95   | 1,383.87      | 595.44                  | 119.59               | 511.59                  | 93.33              | 239.74                              |
| Idaho.....              | 15,000.00                | 8,098.76                 | 2,004.72   | 403.05        | 43.05                   | 90.75                | 476.29                  | 171.02             | 570.64                              |
| Illinois.....           | 15,000.00                | 10,389.97                | 1,422.08   | 20.40         | 431.05                  | 90.75                | 422.40                  | 142.72             | 105.29                              |
| Indiana.....            | 15,000.00                | 10,482.00                | 980.34     | 1,129.24      | 9.32                    | 1.58                 | 442.72                  | .....              | 1,852.53                            |
| Iowa.....               | 15,000.00                | 7,511.86                 | 773.51     | 2,054.68      | 23.29                   | 84.91                | 36.13                   | 467.16             | 766.82                              |
| Kansas.....             | 15,000.00                | 4,391.69                 | 6,844.25   | 125.18        | 70.60                   | 511.47               | 400.32                  | 178.72             | 178.72                              |
| Kentucky.....           | 15,000.00                | 8,620.86                 | 1,246.42   | 485.70        | 671.85                  | 70.60                | 16.56                   | .....              | 105.29                              |
| Louisiana.....          | 15,000.00                | 10,561.95                | 2,093.43   | 586.10        | 409.79                  | 82.79                | 226.99                  | 491.59             | 315.88                              |
| Maine.....              | 15,000.00                | 5,196.03                 | 4,888.64   | 152.48        | 525.94                  | .....                | .....                   | .....              | 129.27                              |
| Maryland.....           | 15,000.00                | 14,785.10                | 214.90     | .....         | .....                   | .....                | .....                   | .....              | .....                               |
| Massachusetts.....      | 15,000.00                | 12,099.49                | 1,280.80   | 704.34        | 13.33                   | .....                | 8.63                    | 39.78              | 119.72                              |
| Michigan.....           | 15,000.00                | 9,301.30                 | 2,075.30   | 1,85          | 149.07                  | 20.53                | 102.67                  | 523.02             | 353.51                              |
| Minnesota.....          | 15,000.00                | 8,724.97                 | 2,980.83   | 925.00        | 203.97                  | .....                | .....                   | 289.55             | 279.55                              |
| Mississippi.....        | 15,000.00                | 6,386.09                 | 3,945.61   | .....         | 217.43                  | 145.87               | 133.89                  | .....              | 1,007.14                            |
| Missouri.....           | 15,000.00                | 11,355.88                | 119.97     | 975.34        | 4.90                    | 115.43               | 28.90                   | 79.35              | 432.59                              |
| Montana.....            | 15,000.00                | 10,211.66                | 1,272.53   | 995.22        | 765.41                  | 62.55                | 62.55                   | .....              | 698.02                              |
| Nebraska.....           | 15,000.00                | 6,325.00                 | 3,616.88   | 671.43        | 973.86                  | 3.30                 | 282.98                  | .....              | 634.13                              |
| Nevada.....             | 15,000.00                | 6,319.47                 | 3,102.45   | 223.91        | 334.03                  | 351.68               | 62.00                   | .....              | 134.42                              |
| New Hampshire.....      | 15,000.00                | 8,849.10                 | 1,423.21   | 1,307.87      | 606.37                  | 238.85               | 665.85                  | 5.50               | 288.66                              |
| New Jersey.....         | 15,000.00                | 8,583.75                 | 1,256.37   | 74.10         | 769.86                  | 38.80                | 1,062.41                | 353.28             | 293.96                              |
| New Mexico.....         | 15,000.00                | 7,854.74                 | 2,458.08   | 1,110.57      | 144.74                  | 98.88                | 289.36                  | 53.06              | 257.58                              |
| New York (State).....   | 1,500.00                 | .....                    | 697.45     | .....         | .....                   | .....                | .....                   | 79                 | .....                               |
| New York (Cornell)..... | 13,500.00                | 4,746.67                 | 2,623.04   | 107.28        | 1,366.21                | 107.26               | 400.15                  | 452.69             | 961.49                              |
| North Dakota.....       | 15,000.00                | 7,148.31                 | 2,922.55   | 104.25        | 424.57                  | 345.97               | 128.72                  | .....              | 23.29                               |
| Ohio.....               | 15,000.00                | 10,924.10                | 3,471.60   | .....         | .....                   | .....                | .....                   | 108.17             | 251.37                              |
| Oklahoma.....           | 15,000.00                | 12,347.48                | 1,554.44   | 1,193.63      | 65.00                   | 259.94               | 3.80                    | 61.44              | 55.47                               |
| Oregon.....             | 7,649.08                 | 5,197.46                 | 1,271.50   | 1,210.96      | 2,152.35                | 52.75                | 39.96                   | 27.49              | 105.97                              |
| Pennsylvania.....       | 15,000.00                | 10,580.67                | 1,371.50   | 2,210.96      | 9,738.39                | 71.94                | .....                   | 9.26               | 195.99                              |



*Expenditures from United States appropriation received under the act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1914—Continued.*

### Classified expenditures—Continued.

| Station.                          | Classified expenditures—Continued. |                    |          |  |                               |                          |                        |           |
|-----------------------------------|------------------------------------|--------------------|----------|--|-------------------------------|--------------------------|------------------------|-----------|
|                                   | Fertilizers,                       | Feeding<br>stuffs, | Library. | Tools, im-<br>plements,<br>and<br>machinery. | Furniture<br>and<br>fixtures. | Scientific<br>apparatus. | Buildings<br>and land. | Balances. |
|                                   |                                    |                    |          |  |                               |                          |                        |           |
| Alabama.....                      | \$361.50                           | \$496.54           | \$485.97 | \$48.50                                      | \$35.15                       | \$120.90                 | \$20.00                | \$457.99  |
| Arizona.....                      | 111.19                             | \$337.15           | 310.88   | 479.89                                       | 60.43                         | 129.50                   | 137.02                 | 328.71    |
| Iowa.....                         | 107.30                             | 996.37             | 1,126.69 | 839.75                                       | 15.95                         | 167.77                   | 141.23                 | 250.94    |
| Missouri.....                     |                                    | 1.45               | 20.34    | 176.81                                       |                               |                          | 87.90                  |           |
| Colorado.....                     |                                    | 58.07              | 565.90   | 248.30                                       | 107.04                        |                          | 433.93                 | 20.00     |
| Connecticut (State) (Storrs)..... | 89.62                              | 3.00               | 455.13   | 60.00  | 72.50                         |                          | 130.36                 |           |
| Delaware.....                     | 516.33                             | 1,485.13           | 80.92    | 136.75                                       |                               | 455.00                   |                        | 509.99    |
| Florida.....                      | 228.83                             | 1,409.97           | 196.89   | 208.42                                       | 513.42                        | 273.25                   | 20.00                  | 248.81    |
| Georgia.....                      | 241.45                             | 163.51             | 821.83   | 402.06                                       | 33.00                         | 189.23                   | 70.00                  | 682.42    |
| Illinois.....                     |                                    | 6.82               | 298.85   | 143.10                                       | 14.66                         | 4.75                     | 346.75                 | 20.00     |
| Indiana.....                      |                                    | 1,236.14           | 18.15    | 558.38                                       | 328.44                        | 59.45                    |                        | 267.85    |
| Iowa.....                         | 1,162.88                           | 3.75               | 129.95   | 57.44  | 1,132.61                      | 12.87                    |                        | 543.76    |
| Kansas.....                       | 2.08                               | 12.00              | 229.29   | 30.25  | 43.84                         | 936.38                   | 20.00                  | \$5.00    |
| Louisiana.....                    | 101.95                             | 648.17             | 174.54   | 881.90                                       | 80.77                         | 145.36                   | 20.00                  | 626.38    |
| Maine.....                        | 60.83                              | 297.83             | 198.00   | 393.71                                       | 134.04                        | 165.77                   | 20.00                  | 346.18    |
| Maryland.....                     | 740.18                             | 807.11             | 452.56   | 182.14                                       | 82.45                         | 7.20                     | 20.00                  | 438.90    |
| Massachusetts.....                | 675.16                             | 30.92              | 20.43    |  | 7.40                          |                          |                        |           |
| Pennsylvania.....                 | 10.00                              | 738.41             | 428.49   | 200.02                                       | 378.58                        | 250.82                   | 378.64                 | 20.00     |
| Michigan.....                     | 52.28                              | 262.72             | 443.91   | 210.08                                       | 411.71                        | 275.00                   | 60.23                  | 7.79      |
| Minnesota.....                    | 1,056.83                           | 13.00              | 593.25   | 224.10                                       | 244.90                        | 376.89                   | 4.38                   | 53.14     |
| Mississippi.....                  |                                    | 978.62             | 55.22    | 328.20                                       | 79.35                         | 131.10                   | 221.38                 | 727.87    |
| Missouri.....                     |                                    | 85.28              | 11.85    | 141.97                                       | 80                            | 137.00                   | 20.00                  | 71.52     |
| Montana.....                      | 951.45                             | 347.16             | 133.14   | 1,433.09                                     | 37.50                         |                          |                        | 87.59     |
| Nebraska.....                     |                                    | 25.00              | 737.32   | 1,359.60                                     | 338.19                        | 8.50                     | 175.33                 | 20.00     |
| New Hampshire.....                | 89.70                              | 272.29             | 413.33   | 208.11                                       | 271.05                        | 15.00                    | 183.42                 | 48.83     |
| New Jersey.....                   | 18.19                              |                    | 384.41   | 274.82                                       | 222.60                        | 332.10                   | 1,035.26               | 499.52    |
| New Mexico.....                   | 64.00                              | 1,239.77           | 4.21     | 326.51                                       | 179.05                        | 2.50                     | 173.15                 | 222.50    |
| New York (State).....             |                                    |                    | 45.83    | 214.06                                       |                               | 262.72                   |                        | 56.38     |
| New York (Cornell).....           | 166.30                             | 1.88               | 61.27    | 687.02                                       | 384.00                        | 295.75                   | 765.35                 | .36       |
| North Carolina.....               | 1,103.97                           | 952.22             |          |  |                               | 65.81                    | 311.38                 | 20.00     |
| North Dakota.....                 |                                    |                    |          |  |                               | 142.20                   | 150.00                 | 347.43    |
| Oklahoma.....                     |                                    |                    |          |  |                               | 66.85                    | 308.71                 | 550.00    |
| Pennsylvania.....                 | 8.12                               | 234.80             | 16.65    | 268.81                                       |                               |                          |                        | 3.26      |
| Region.....                       | 13.27                              | 1,760.63           | 40.25    | 75.50  | 50.70                         | 52.13                    | 233.24                 | 52.15     |



*Expenditures from United States appropriation received under the act of Mar. 16, 1906 (Adams Act), for the year ended June 30, 1914.*

| Station.                  | Amount of appropriation. | Classified expenditures. |            |                         |                      |                         |                    |
|---------------------------|--------------------------|--------------------------|------------|-------------------------|----------------------|-------------------------|--------------------|
|                           |                          | Salaries.                | Labor.     | Postage and stationery. | Freight and express. | Heat, light, and water. | Chemical supplies. |
| Alabama.....              | \$15,000.00              | \$9,881.67               | \$1,550.90 | \$163.85                | \$138.27             | \$360.19                | \$195.93           |
| Arizona.....              | 15,000.00                | 10,889.06                | 1,780.26   | 36.19                   | 95.33                | 10,811                  | 53.82              |
| Arkansas.....             | 15,000.00                | 10,889.46                | 1,734.92   | 50.63                   | 151.39               | 102.38                  | 403.24             |
| California.....           | 15,000.00                | 10,179.78                | 1,455.77   | 20.44                   | 38.19                | 737.01                  | 188.55             |
| Colorado.....             | 15,000.00                | 11,568.04                | 322.21     | 36.98                   | 112.50               | ...<br>...<br>...       | 811.65             |
| Connecticut (State).....  | 15,000.00                | 15,309.41                | 371.37     | 55.37                   | 95.10                | 596.73                  | 113.45             |
| Connecticut (Storrs)..... | 15,000.00                | 15,185.40                | 800.66     | 2.75                    | 5.66                 | 128.47                  | 670.99             |
| Delaware.....             | 15,000.00                | 11,212.06                | 306.00     | 32.68                   | 33.90                | 134.09                  | 202.13             |
| Florida.....              | 15,000.00                | 1,061.50                 | 1,045.18   | 169.96                  | 61.96                | 698.95                  | 320.16             |
| Georgia.....              | 15,000.00                | 8,677.50                 | 1,523.84   | 107.23                  | 210.71               | 228.01                  | 187.67             |
| Idaho.....                | 15,000.00                | 10,633.27                | 1,412.75   | 56.55                   | 240.14               | 337.20                  | 344.32             |
| Illinois.....             | 15,000.00                | 12,683.42                | 1,522.86   | 13.85                   | 1.55                 | 68.84                   | 38.10              |
| Indiana.....              | 15,000.00                | 11,780.60                | 1,633.17   | 40.91                   | 9.47                 | 133.34                  | 120.23             |
| Iowa.....                 | 15,000.00                | 10,671.12                | 1,191.94   | 25.30                   | 1.92                 | 85.90                   | 2,652.52           |
| Kansas.....               | 15,000.00                | 9,406.15                 | 3,124.38   | 3.90                    | 54.06                | 121.90                  | 1,237.36           |
| Kentucky.....             | 15,000.00                | 11,187.91                | 438.25     | 37.60                   | 30.01                | 104.39                  | 334.43             |
| Louisiana.....            | 15,000.00                | 11,575.52                | 418.84     | 27.54                   | 71.67                | 285.85                  | 151.12             |
| Maine.....                | 15,000.00                | 11,049.58                | 107.86     | 96.85                   | 100.78               | 105.41                  | 147.17             |
| Maryland.....             | 15,000.00                | 9,804.96                 | 533.17     | 127.75                  | 6.40                 | 654.74                  | 145.96             |
| Massachusetts.....        | 15,000.00                | 13,047.20                | 901.01     | 26.38                   | 13.26                | 1,207.56                | 132.57             |
| Michigan.....             | 15,000.00                | 11,066.78                | 949.00     | 1.73                    | 6.35                 | 1,207.56                | 292.55             |
| Minnesota.....            | 15,000.00                | 13,165.00                | 1,040.25   | 50.24                   | ...<br>...<br>...    | 218.02                  | 68.09              |
| Mississippi.....          | 15,000.00                | 8,289.68                 | 4,181.27   | 60.77                   | 42.30                | 9.63                    | 107.31             |
| Missouri.....             | 15,000.00                | 12,288.71                | 3,077.54   | 73.27                   | 99.76                | 97.31                   | 1,093.17           |
| Montana.....              | 15,000.00                | 12,170.10                | 1,197.86   | 71.24                   | 96.54                | 5.47                    | 852.80             |
| Nebraska.....             | 15,000.00                | 9,382.80                 | 2,199.43   | 35.45                   | 39.97                | 235.73                  | 130.84             |
| Nevada.....               | 15,000.00                | 10,918.00                | 1,040.00   | 1,033.32                | 58.60                | 109.09                  | 638.23             |
| New Hampshire.....        | 15,000.00                | 1,508.00                 | 1,465.00   | 1,465.17                | 17.00                | 175.07                  | 61.65              |
| New Jersey.....           | 15,000.00                | 1,508.00                 | 1,465.00   | 1,465.17                | 2.22                 | 285.20                  | 168.51             |
| New Mexico.....           | 15,000.00                | 1,499.73                 | 1,301.04   | 53.03                   | 451.37               | 350.64                  | 686.39             |
| New York (State).....     | 15,000.00                | 1,499.96                 | 1,932.82   | 1,245.51                | 13.62                | 510.95                  | 73.50              |
| New York (Cornell).....   | 13,500.00                | 8,388.01                 | 1,109.16   | 119.06                  | 119.06               | 1,413.62                | 272.11             |
| North Carolina.....       | 15,000.00                | 13,736.00                | 410.81     | 12.85                   | 12.85                | 352.78                  | 65.53              |
| North Dakota.....         | 15,000.00                | 1,511.80                 | 1,467.70   | 16.92                   | 3.60                 | 260.77                  | 4.50               |
| Ohio.....                 | 15,000.00                | 12,789.02                | 1,632.92   | 1,044.51                | 1,044.51             | 135.36                  | 75.40              |
| Oklahoma.....             | 15,317.91                | 6,166.66                 | 1,136.28   | 1,044.92                | 13.45                | 37.52                   | 283.66             |
| Oregon.....               | 15,000.00                | 11,098.88                | 1,044.26   | 1,044.26                | 10.00                | 287.54                  | 304.00             |
| Pennsylvania.....         | 15,000.00                | 10,108.19                | 1,225.23   | 1,225.23                | 10.00                | 132.10                  | 851.51             |

| Rhode Island   | 8,574.78   | 3,277.89   | 32.71     | 139.21   | 402.90   | 154.05   | 375.99    |           |  |
|----------------|------------|------------|-----------|----------|----------|----------|-----------|-----------|--|
| South Carolina | 8,433.34   | 3,334.07   | 10.73     | 154.86   | 100.35   | 430.54   | 350.64    |           |  |
| South Dakota   | 10,003.38  | 2,979.64   | 22.41     | 211.42   | 40.82    | 343.04   | 119.81    |           |  |
| Tennessee      | 11,155.02  | 9,656.44   | 14.80     | 71.67    | 232.44   | 677.85   | 140.15    |           |  |
| Texas          | 10,303.18  | 1,698.66   | 12.46     | 179.80   | 460.36   | 205.53   |           |           |  |
| Utah           | 8,912.52   | 2,501.57   | 40.24     | 87.33    | 267.94   | 1,254.12 | 163.21    |           |  |
| Vermont        | 8,823.90   | 2,433.03   | 47.06     | 9.58     | 423.33   | 487.28   | 387.35    |           |  |
| Virginia       | 9,019.72   | 2,091.45   | 66.41     | 136.32   | 91.30    | 728.37   | 147.31    |           |  |
| Washington     | 8,025.40   | 4,100.45   | 7.49      | 121.25   | 84.36    | 476.45   | 292.41    |           |  |
| West Virginia  | 10,134.56  | 2,633.77   | 20.47     | 44.52    | 44.10    | 745.52   | 1,017.88  |           |  |
| Wisconsin      | 8,210.00   | 2,147.00   | 26.43     | 112.83   | 182.02   | 335.00   | 124.63    |           |  |
| Wyoming        | 10,883.18  | 821.23     | 9.25      |          |          |          |           |           |  |
| Total          | 713,517.91 | 488,992.55 | 74,078.87 | 2,170.86 | 4,273.30 | 6,116.69 | 24,302.43 | 15,013.91 |  |

*Expenditures from United States appropriation received under the act of March 16, 1906 (Adams Act), for the year ended June 30, 1914—Continued.*

### Classified expenditures—Continued.



*Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, and Mar. 16, 1906.*

| State or Territory.   | Hatch Act.   |             | Adams Act.   |             |
|-----------------------|--------------|-------------|--------------|-------------|
|                       | 1888-1913    | 1914        | 1906-1913    | 1914        |
| Alabama.....          | \$389,199.34 | \$15,000.00 | \$86,619.89  | \$15,000.00 |
| Arizona.....          | 354,803.15   | 15,000.00   | 90,000.00    | 15,000.00   |
| Arkansas.....         | 388,151.12   | 14,988.00   | 90,000.00    | 14,900.00   |
| California.....       | 390,000.00   | 15,000.00   | 89,926.84    | 15,000.00   |
| Colorado.....         | 389,718.82   | 15,000.00   | 88,638.93    | 15,000.00   |
| Connecticut.....      | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Dakota Territory..... | 56,250.00    |             |              |             |
| Delaware.....         | 389,382.87   | 15,000.00   | 86,750.12    | 15,000.00   |
| Florida.....          | 389,966.06   | 15,000.00   | 89,996.06    | 15,000.00   |
| Georgia.....          | 389,981.55   | 15,000.00   | 89,720.50    | 11,640.17   |
| Idaho.....            | 314,824.13   | 15,000.00   | 85,842.22    | 15,000.00   |
| Illinois.....         | 389,564.95   | 15,000.00   | 89,851.62    | 15,000.00   |
| Indiana.....          | 389,901.19   | 15,000.00   | 85,000.00    | 15,000.00   |
| Iowa.....             | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Kansas.....           | 389,995.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Kentucky.....         | 389,996.57   | 15,000.00   | 90,000.00    | 15,000.00   |
| Louisiana.....        | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Maine.....            | 389,999.62   | 15,000.00   | 90,000.00    | 15,000.00   |
| Maryland.....         | 389,967.40   | 15,000.00   | 89,763.99    | 15,000.00   |
| Massachusetts.....    | 389,617.70   | 15,000.00   | 90,000.00    | 15,000.00   |
| Michigan.....         | 389,676.10   | 15,000.00   | 86,341.20    | 15,000.00   |
| Minnesota.....        | 390,000.00   | 15,000.00   | 89,345.74    | 15,000.00   |
| Mississippi.....      | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Missouri.....         | 385,097.24   | 15,000.00   | 90,000.00    | 15,000.00   |
| Montana.....          | 300,000.00   | 15,000.00   | 87,417.04    | 15,000.00   |
| Nebraska.....         | 389,932.16   | 15,000.00   | 90,000.00    | 15,000.00   |
| Nevada.....           | 389,939.32   | 14,275.00   | 89,663.58    | 13,516.70   |
| New Hampshire.....    | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| New Jersey.....       | 389,961.97   | 14,988.00   | 89,558.78    | 15,000.00   |
| New Mexico.....       | 354,998.90   | 14,510.15   | 90,000.00    | 15,000.00   |
| New York.....         | 389,860.18   | 15,000.00   | 89,880.81    | 15,000.00   |
| North Carolina.....   | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| North Dakota.....     | 331,778.34   | 15,000.00   | 90,000.00    | 15,000.00   |
| Ohio.....             | 390,000.00   | 15,000.00   | 88,514.02    | 15,000.00   |
| Oklahoma.....         | 321,919.88   | 7,649.08    | 77,842.65    | 8,517.91    |
| Oregon.....           | 375,156.64   | 15,000.00   | 85,000.00    | 15,000.00   |
| Pennsylvania.....     | 389,967.43   | 15,000.00   | 89,995.41    | 15,000.00   |
| Rhode Island.....     | 390,000.00   | 15,000.00   | 87,464.20    | 15,000.00   |
| South Carolina.....   | 339,542.15   | 15,000.00   | 88,460.12    | 15,000.00   |
| South Dakota.....     | 333,250.00   | 15,000.00   | 85,000.00    | 15,000.00   |
| Tennessee.....        | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Texas.....            | 390,000.00   | 15,000.00   | 87,592.26    | 15,000.00   |
| Utah.....             | 255,000.00   | 15,000.00   | 89,821.94    | 15,000.00   |
| Vermont.....          | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Virginia.....         | 387,826.80   | 15,000.00   | 89,949.56    | 15,000.00   |
| Washington.....       | 328,414.70   | 15,000.00   | 86,080.11    | 15,000.00   |
| West Virginia.....    | 389,968.71   | 15,000.00   | 87,859.12    | 15,000.00   |
| Wisconsin.....        | 390,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Wyoming.....          | 375,000.00   | 15,000.00   | 90,000.00    | 15,000.00   |
| Total.....            | 8,118,609.99 | 711,410.23  | 4,257,896.71 | 705,574.78  |

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NOTE.—The abbreviations "Ala. College," "Conn. State," "Mass.," "P.R.," etc., after entries refer to the work of the respective experiment stations, and the words "bulletin," "circular," "memoir," etc., before such abbreviations refer to publications of the respective experiment stations mentioned by title in the text.

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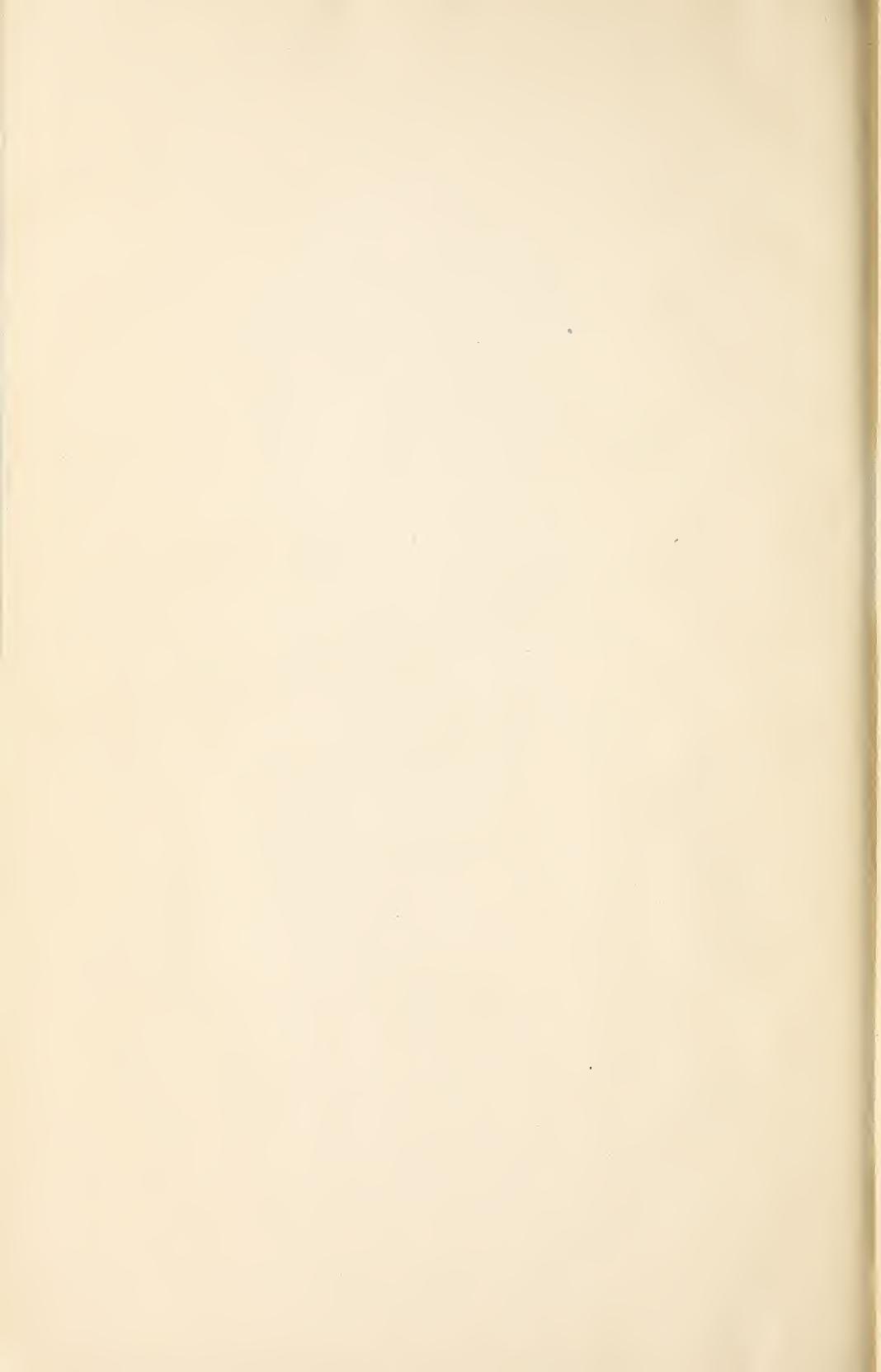
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